Grange Hill: Post-Decommissioning Surface Persistence and Landscape Expression

Evidence from Historical Imagery, UAV Survey and LiDAR Elevation Differencing

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1. Introduction

Grange Hill (Grange Road), Singleton, was one of Cuadrilla's original shale gas exploration sites in Lancashire. The exploratory well was drilled in 2011 and subsequently retained for monitoring and pressure observation before plugging, abandonment and restoration. Restoration works commenced in 2018, and the site was formally returned to agricultural use later that year.

The site now provides an unusual opportunity to examine the physical expression of a former hydrocarbon exploration site across several distinct stages of its lifecycle. Historical aerial imagery, UAV surveys and national LiDAR data together provide a record spanning later operation, decommissioning, restoration and post-restoration agricultural use.

This study is concerned with what remains observable after visible infrastructure has been removed.

Restoration is commonly described through the completion of specified works, removal of infrastructure and return of land to an approved after-use. These are important procedural and land-use outcomes. They do not, however, necessarily establish that the restored land has returned to a defined physical, hydrological or material condition.

For restoration to function as a verifiable outcome rather than solely as a completed activity, the expected condition of the land must be sufficiently defined to allow later comparison. This may include expectations relating to ground level, drainage performance, soil profile, vegetation recovery, material condition and the persistence or disappearance of former engineered features.

Without such criteria, it may be difficult to distinguish between:

- normal recovery following major ground disturbance;
- expected long-term construction legacy;
- ordinary agricultural or seasonal variation;
- and persistent conditions requiring further assessment.

This distinction is not dependent upon agreement over mechanism. Observers may reasonably disagree about the origin or significance of a particular feature. Nevertheless, where an apparently unusual condition is persistent, spatially coherent or repeated across independent datasets, proportionate testing provides a responsible means of determining whether the restored land is behaving as expected.

The purpose of this study is therefore not to infer harm from visual difference or to attribute observed features to well construction, operation or abandonment. It is to examine whether identifiable surface expressions persisted through and after restoration, whether those expressions are corroborated across independent forms of evidence, and whether the available record is sufficient to evaluate them against a defined restoration outcome.

Particular attention is given to:

- the continuing visibility of the former site and drainage geometry;
- recurring vegetation and moisture differentiation;
- visibly distinctive sediment staining documented before restoration;
- and areas of elevation-derived surface form identifiable within LiDAR differencing between 2018 and 2022.

The sediment staining is included as an observed material condition rather than as evidence of contamination. Its composition cannot be determined from imagery. Its presence nevertheless raises the procedural question of whether visibly altered material was recognised, sampled and classified before restoration changed or removed the original surface condition.

The analysis is comparative rather than diagnostic. Aerial imagery records visible surface appearance, vegetation, water and sediment conditions. LiDAR differencing records apparent elevation change between survey epochs. These datasets cannot independently determine mechanism, and spatial correspondence between them does not establish causation.

Their combined value lies in testing persistence and spatial coherence.

The study therefore asks:

1. Which elements of the former site and surrounding landscape remained identifiable after restoration?
2. Do features visible in the photographic chronology also possess measurable expression within an independent elevation dataset?
3. Was the visibly stained material documented before restoration subject to formal recognition, sampling or classification?
4. What criteria, if any, were used to determine that the restored land had reached its intended physical and environmental condition?
5. What does the Grange Hill record imply for the design of post-operational monitoring and verification at comparable sites?

Grange Hill is treated here as a case study in post-operational landscape behaviour. The study does not determine whether restoration failed, whether contamination occurred, or whether any observed feature arose from a continuing subsurface process. It examines a more fundamental question: whether formal completion of restoration was accompanied by an evidential framework capable of demonstrating that the land was behaving as intended.

In this study, successful restoration is not defined as the complete disappearance of all evidence of prior land disturbance. It is understood as the achievement of a documented and verifiable condition consistent with the approved after-use and expected recovery of the site.

The wider relevance is procedural and governance-based. Where the potential consequences of incomplete characterisation are significant, proportionate investigation of persistent or apparently unusual conditions does not require a prior finding of harm. It is a means of testing uncertainty before that uncertainty is normalised, obscured by later land use or rendered impossible to resolve.

2. Site setting and chronology

Grange Hill is located within agricultural land near Singleton on the Fylde coastal plain in Lancashire. The former wellsite occupied an engineered footprint within a wider landscape of cultivated fields, field boundaries and local drainage features.

The following figures establish the location of the site and summarise its progression through late operation, decommissioning, restoration and return to agricultural use. They provide the spatial and chronological framework for the later photographic and LiDAR observations.

This context is particularly relevant because several post-restoration surface expressions remain spatially associated with the former site footprint and drainage geometry.

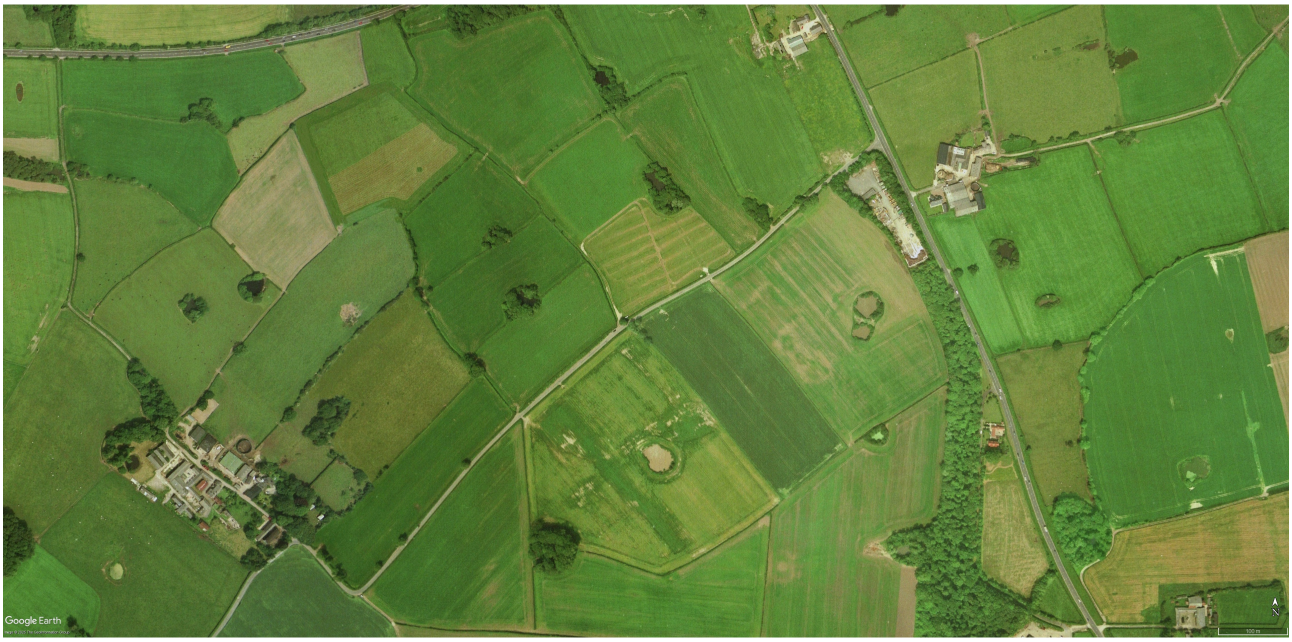

Figure 1: Pre-development imagery shows a low-relief agricultural landscape containing visible ponds, drainage features and areas of contrasting vegetation or moisture expression.

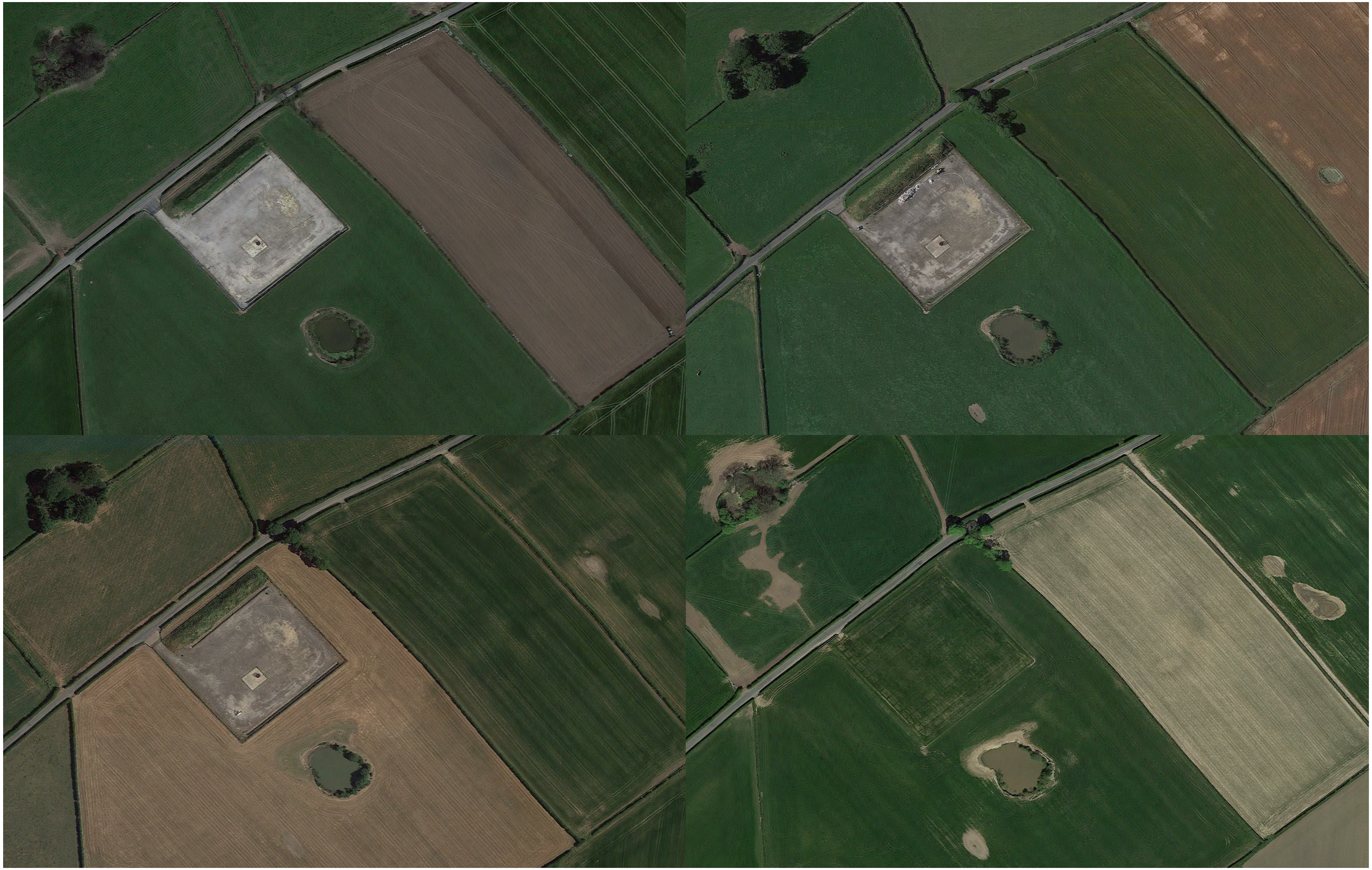

Figure 2: Evolution of the Grange Hill site from late operational phase through to post-restoration conditions. The wellsite is visible in 2015, and has been removed by 2020. The former site footprint remains identifiable within the restored field through tonal and vegetation contrasts visible in aerial imagery.

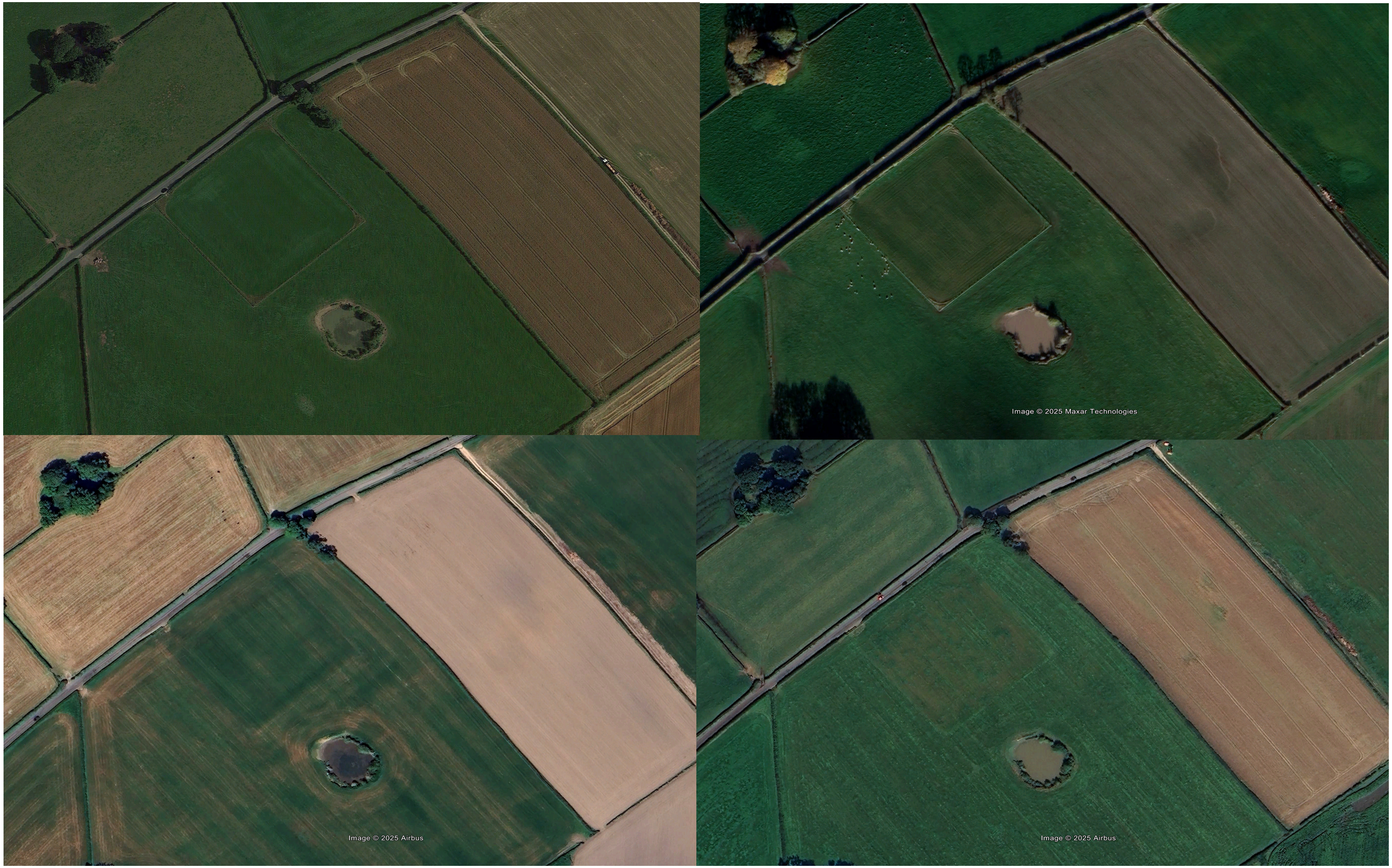

Image © 2025 Maxar Technologies

Image © 2025 Airbus

Image © 2025 Airbus

Figure 3: Imagery between 2021 and 2024 shows the former wellsite footprint remaining visible despite removal of fencing and surface infrastructure. The square footprint consistently exhibits a distinct tonal response relative to surrounding fields. In 2021 and particularly 2024, a reddish vegetation tone is apparent within the former wellsite boundary and is largely absent from adjacent areas.

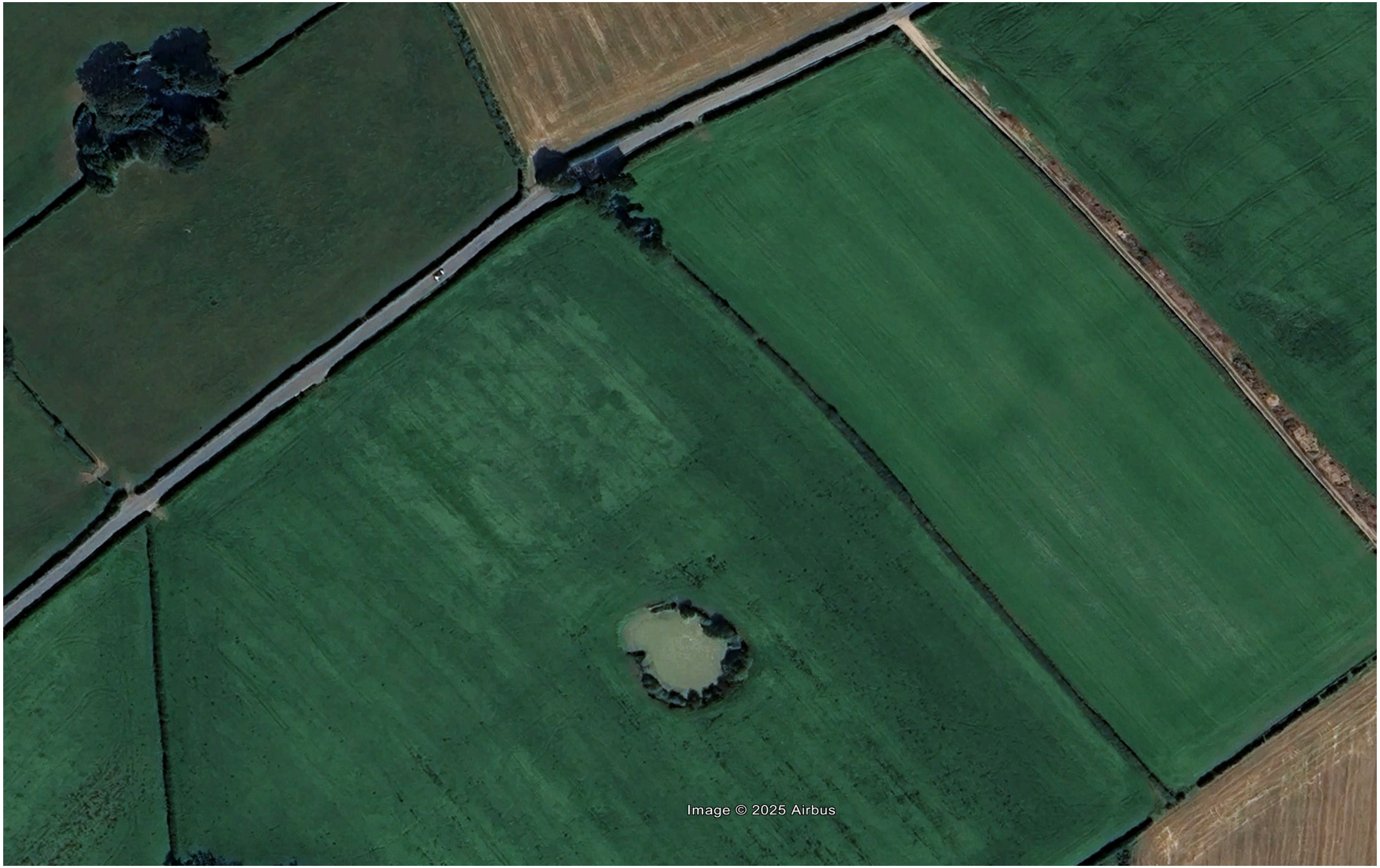

Figure 4: August 2025 imagery showing the former wellsite footprint remaining discernible within the restored field approximately seven years after decommissioning. The rectangular area corresponds closely with the former site boundary and remains distinguishable from the surrounding vegetation despite the removal of surface infrastructure and perimeter fencing.

3. Pre-Restoration and Decommissioning Observations

UAV surveys undertaken during the later operational period onwards provide additional context regarding surface conditions prior to restoration. The September 2017 imagery captures the site while infrastructure remained in place and before decommissioning and restoration works commenced.

These observations establish a visual baseline against which subsequent restoration and post-restoration conditions can be compared.

All images are direct reproductions of original JPEG files. DNG reproductions are screenshots from DaVinci Resolve and are not calibrated for colour or white balance; each has been adjusted for visibility only.

The underlying image archive and associated metadata have been retained in their original structure. Public repository release is planned following legal review. The material is available on request in the interim.

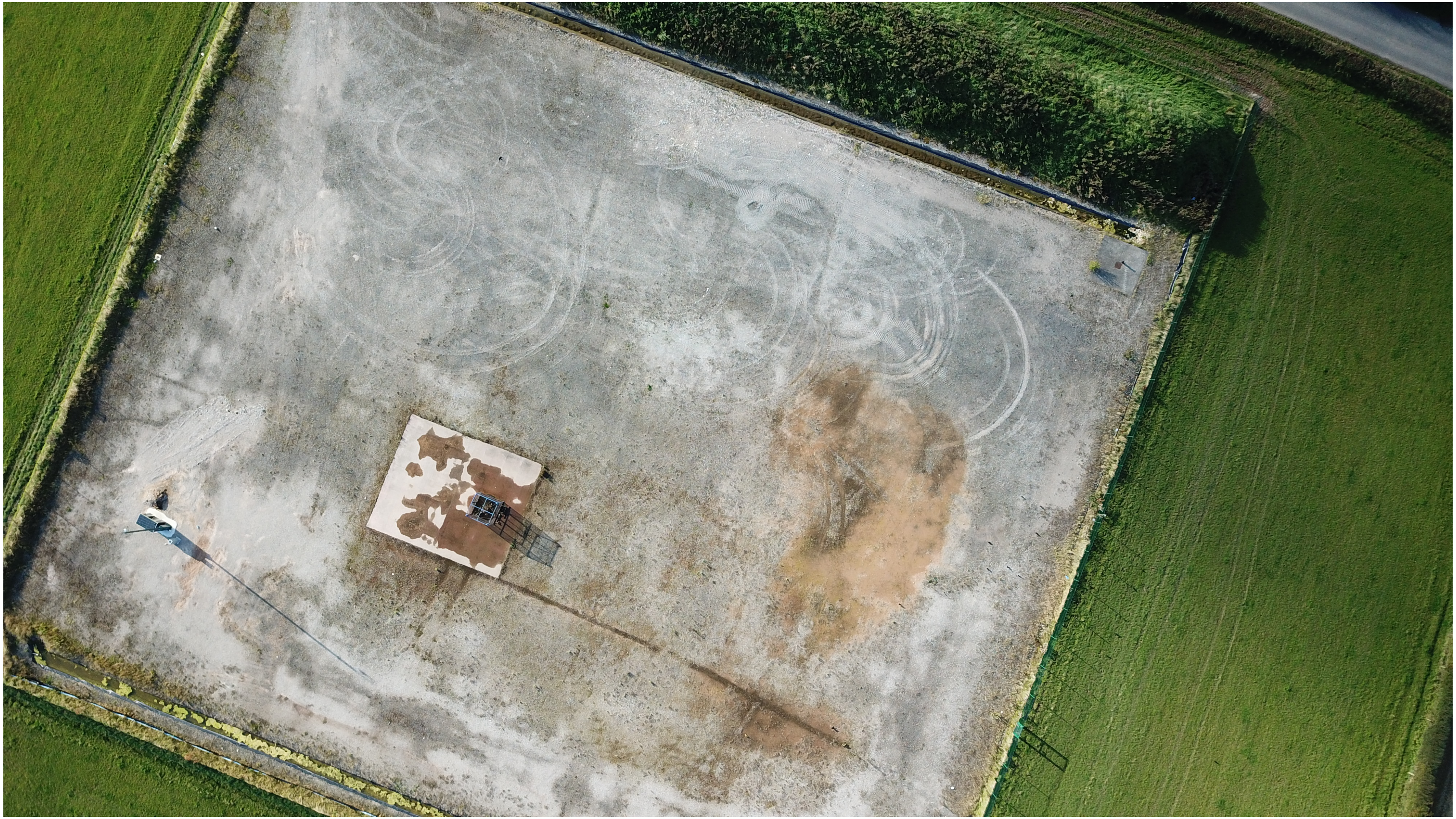

Figure 5: UAV imagery from September 2017 showing the operational wellsite prior to restoration. The image records the engineered pad surface, perimeter drainage infrastructure, central wellhead installation, areas of standing water, sediment staining and spatial variability in surface condition across the pad.

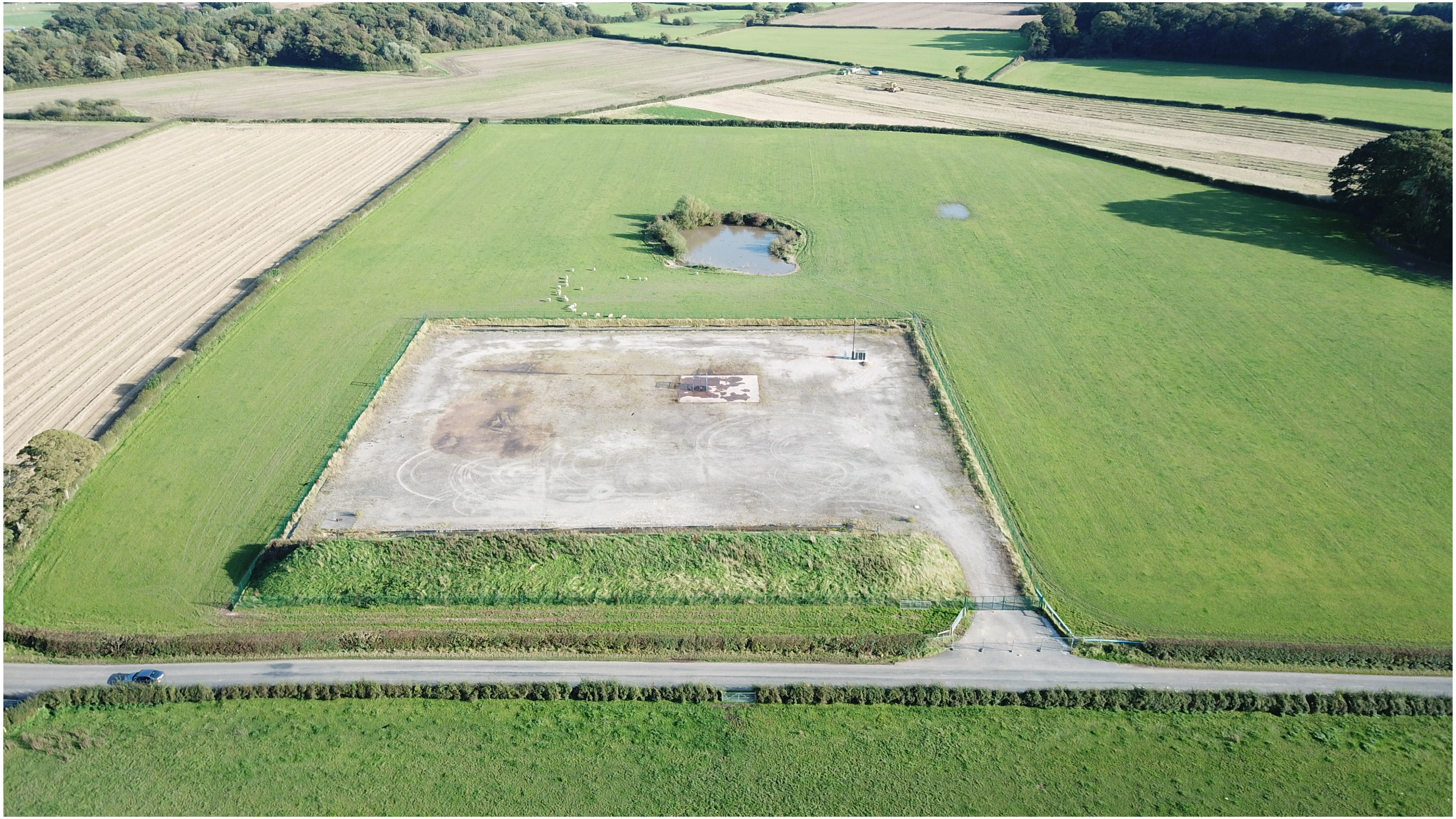

Figure 6: Wider UAV perspective showing areas of standing water and sediment staining on the engineered pad, together with the relationship between the site, surrounding agricultural land, local drainage features and the adjacent pond. A substantial earth bund is visible along the roadside margin. The 2013 EIA scoping report identifies this feature as a stockpile of topsoil and subsoil removed before construction of the pad.

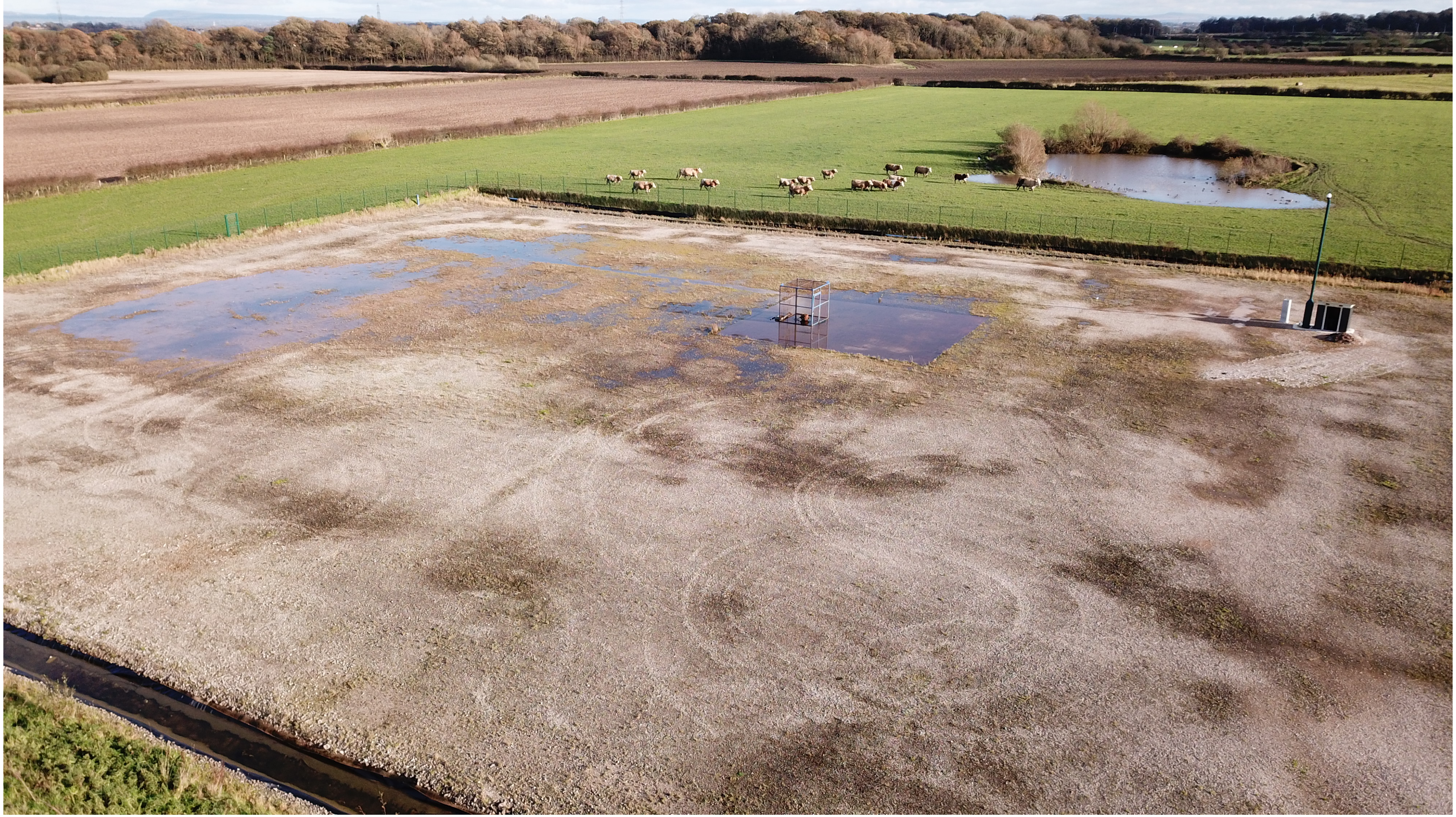

Figure 7: Areas of standing water are visible across the eastern and southern portions of the engineered pad. Dark-toned surface expressions occur near the site entrance and extend across several parts of the gravel surface. Variability in surface colour, moisture and sediment distribution is visible across the site.

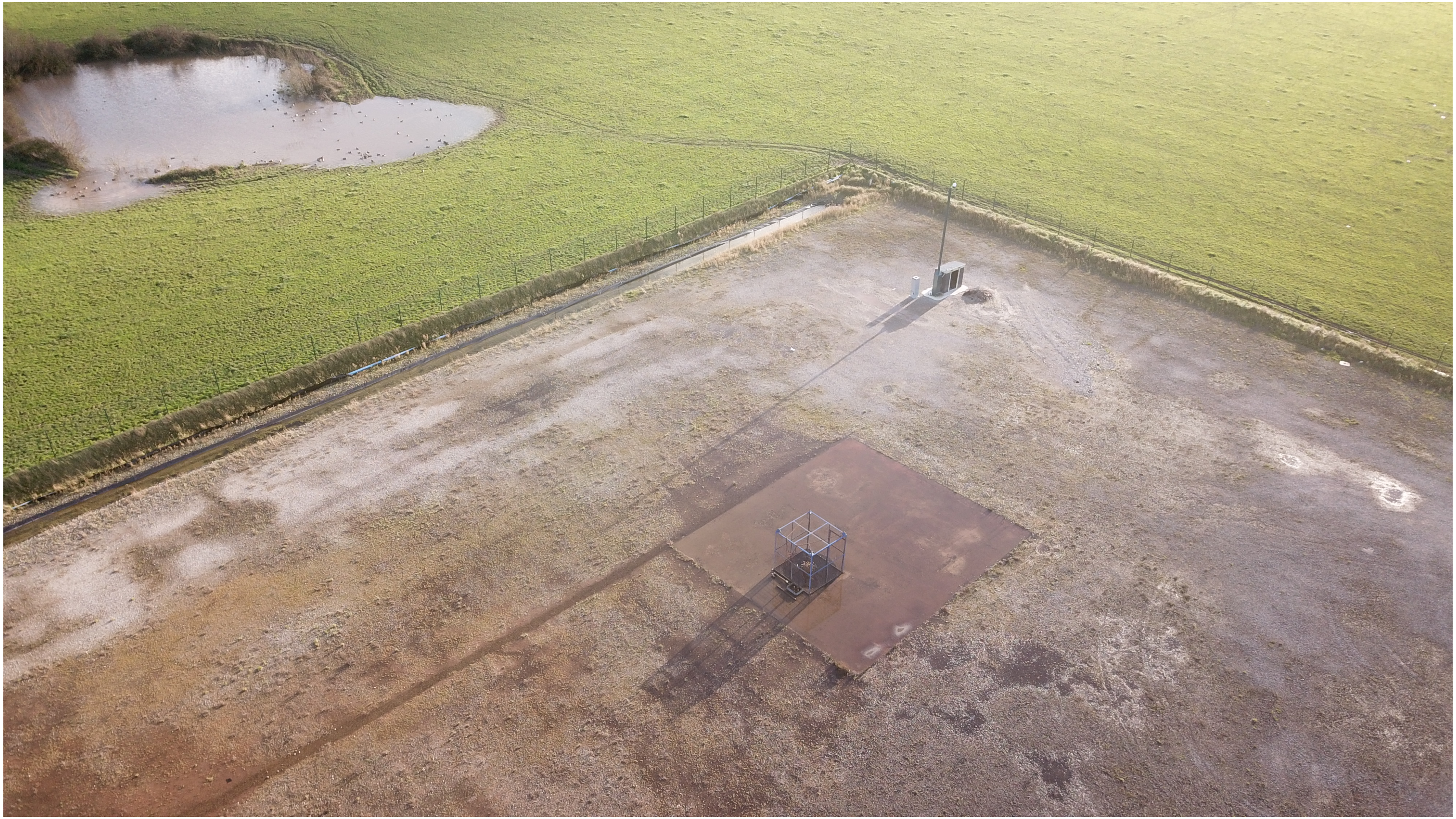

Figure 8: Standing water is present within and around the well cellar. Red-brown sediment is visible around the cellar area, together with a lighter-toned band extending across the gravel surface. Variations in colour, moisture expression and sediment distribution are evident across the immediate vicinity of the well installation.

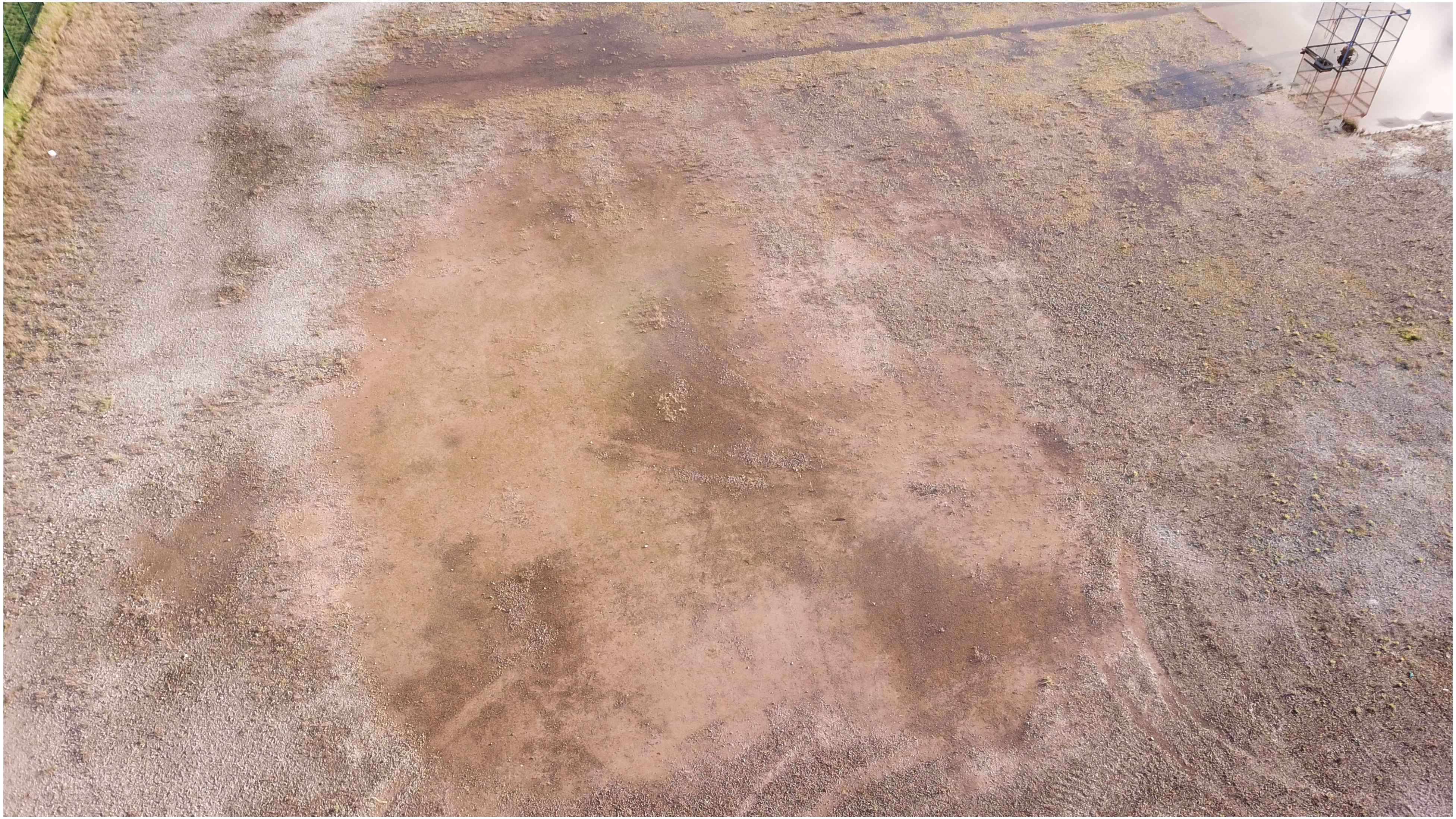

Figure 9: Red-brown and yellow-toned surface staining is visible north-east of the well cellar. Dark-toned linear and branching patches extend across the gravel surface and are visually distinct from the surrounding material.

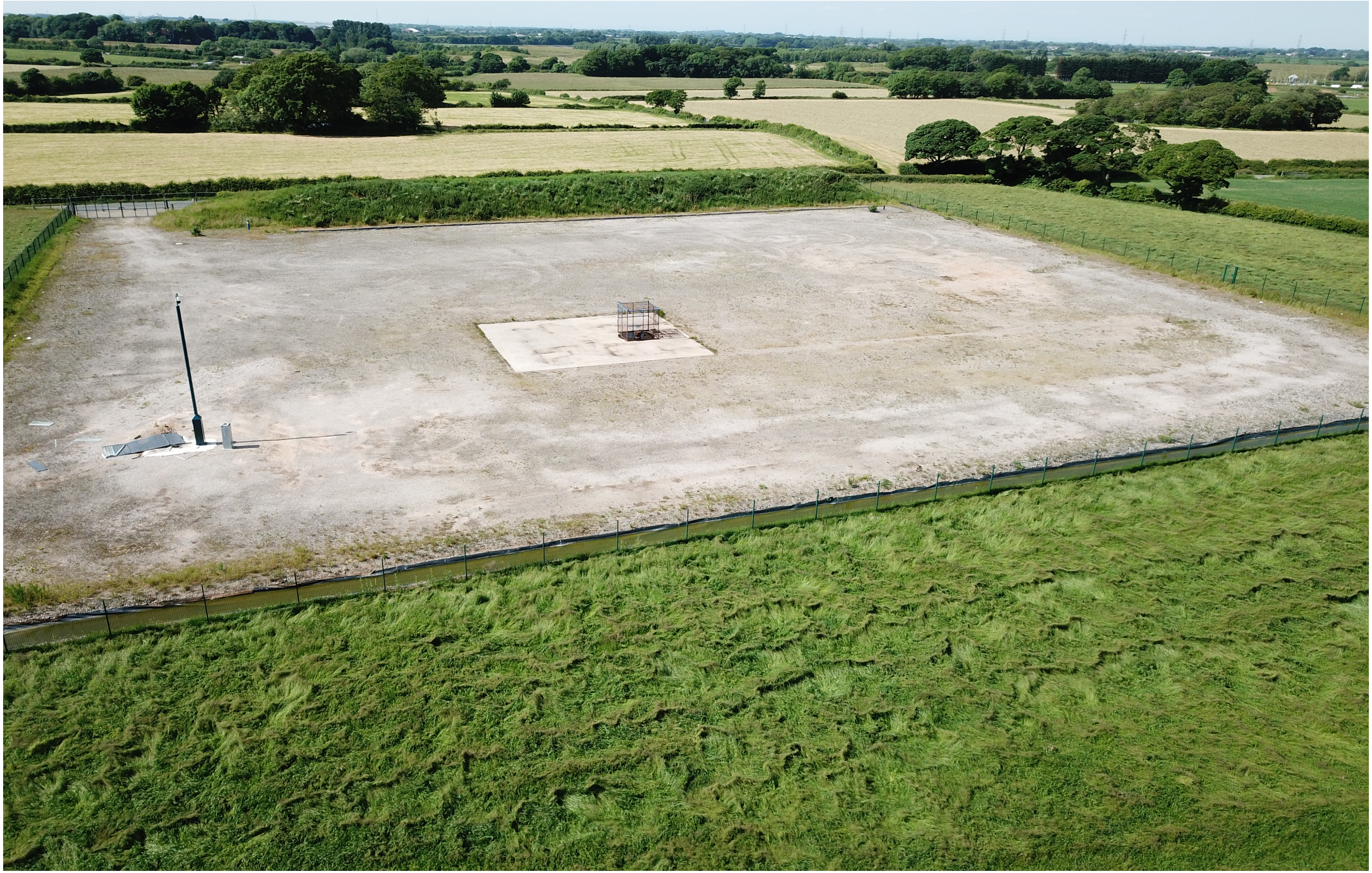

Figure 10: In June 2018, areas previously occupied by standing water exhibit darker-toned gravel patches and continuing surface staining. Several locations retain reddish-brown and lighter-toned deposits visible during earlier surveys. The distribution extends across the pad and includes the vicinity of the well cellar.

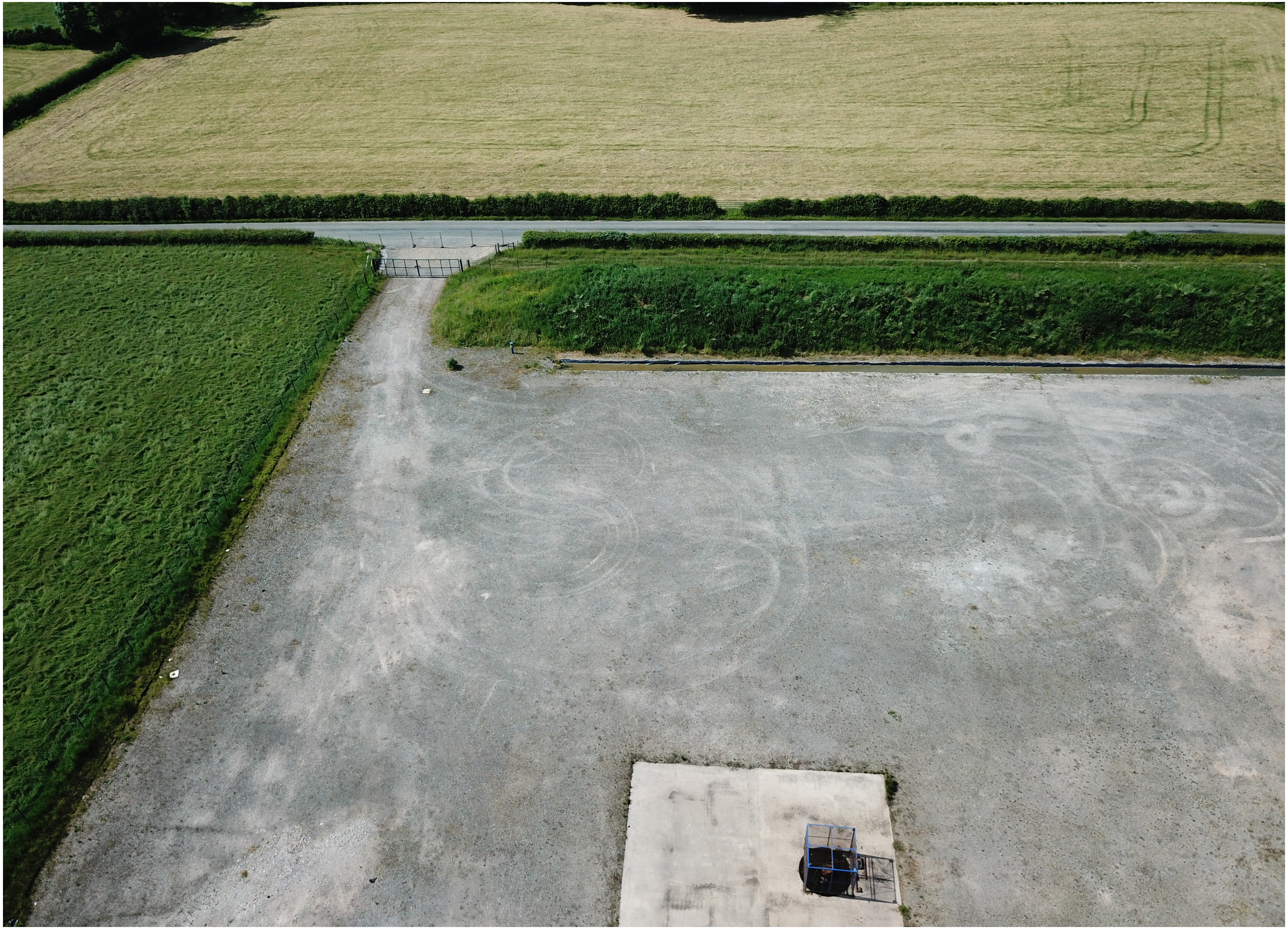

Figure 11: Areas previously characterised by darker-toned surface expressions appear lighter in colour during this survey. The image illustrates temporal variability in surface appearance between successive observations.

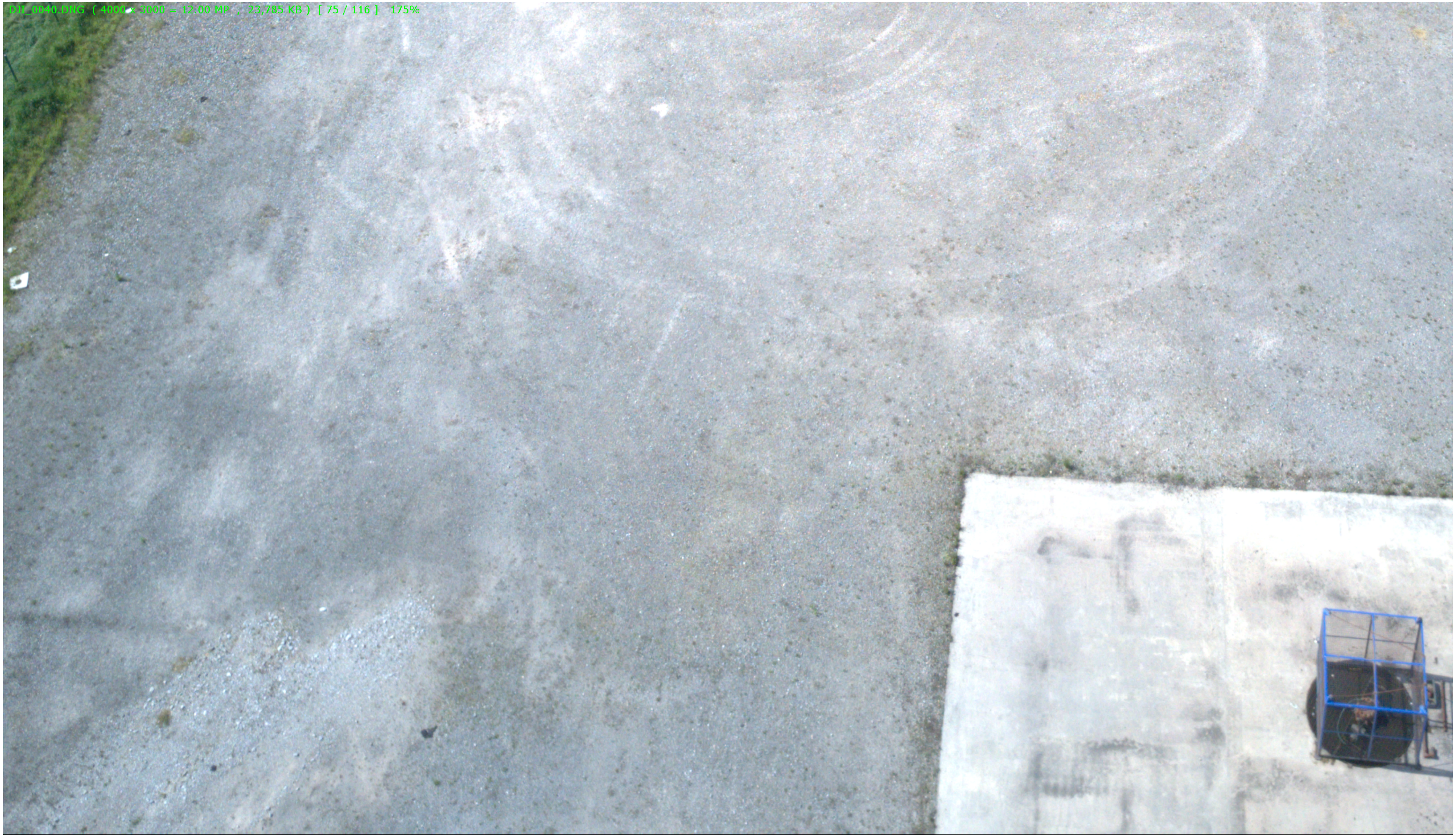
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Figure 12: Gravel immediately south-west of the well cellar exhibits tonal variation and fine-textured surface deposits. The features are visually distinct from the surrounding gravel and form part of a broader pattern visible elsewhere across the pad.

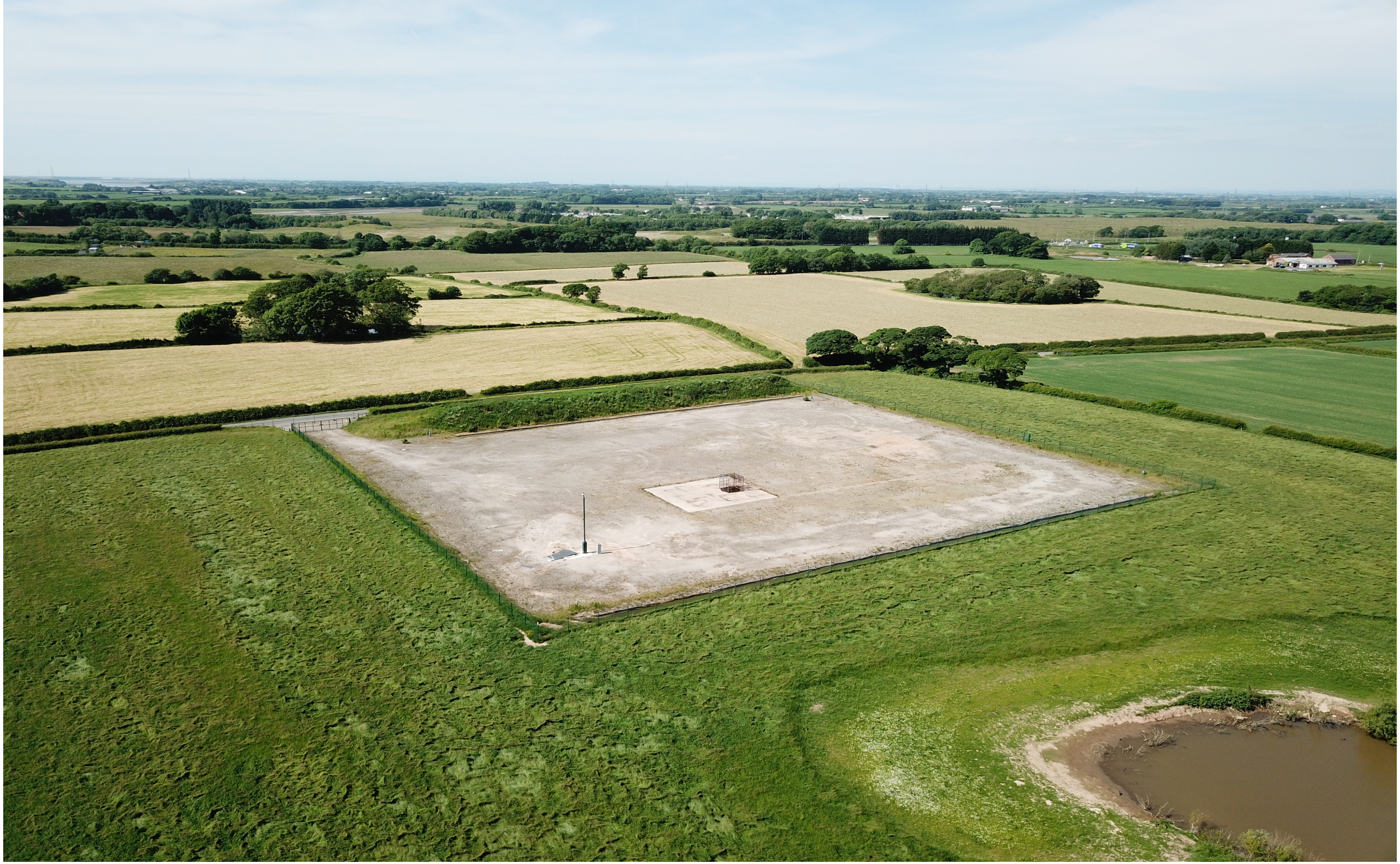

Figure 13: Wider site context showing the former wellsite, perimeter drainage ditch, and adjacent pond. Despite the absence of widespread standing water across the pad surface at the time of survey, water levels within the perimeter ditch appear visually similar to those documented during earlier surveys when extensive ponding was present across the pad. Exposed margins around the adjacent pond indicate lower water levels relative to previous observations.

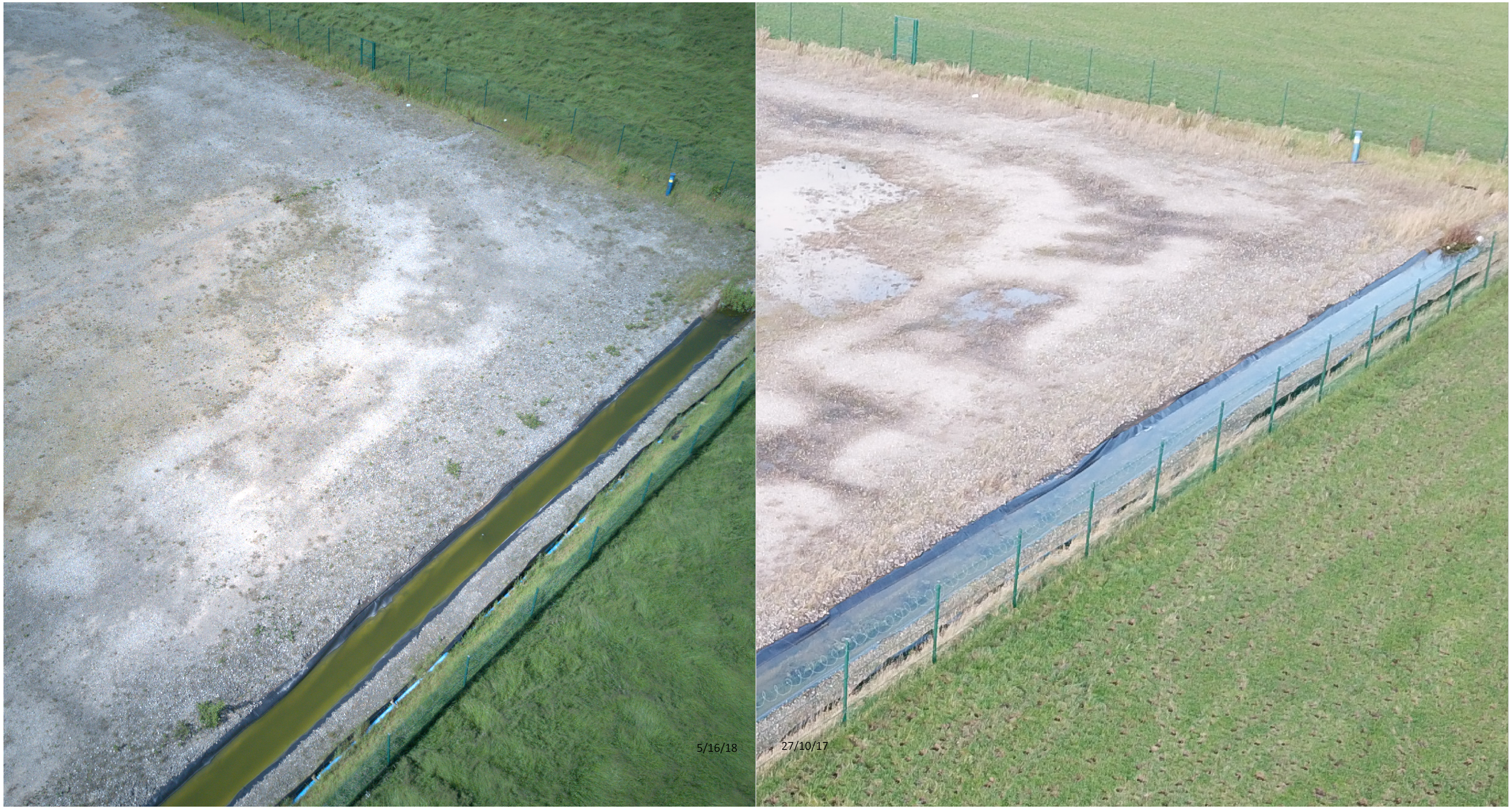

Figure 14: Comparison of perimeter ditch conditions. Later survey (left) and earlier survey (right). The earlier survey shows extensive standing water across the pad surface, whereas the later survey was acquired under substantially drier surface conditions. Despite these differing pad conditions, water levels within the perimeter ditch appear visually comparable between the two surveys.

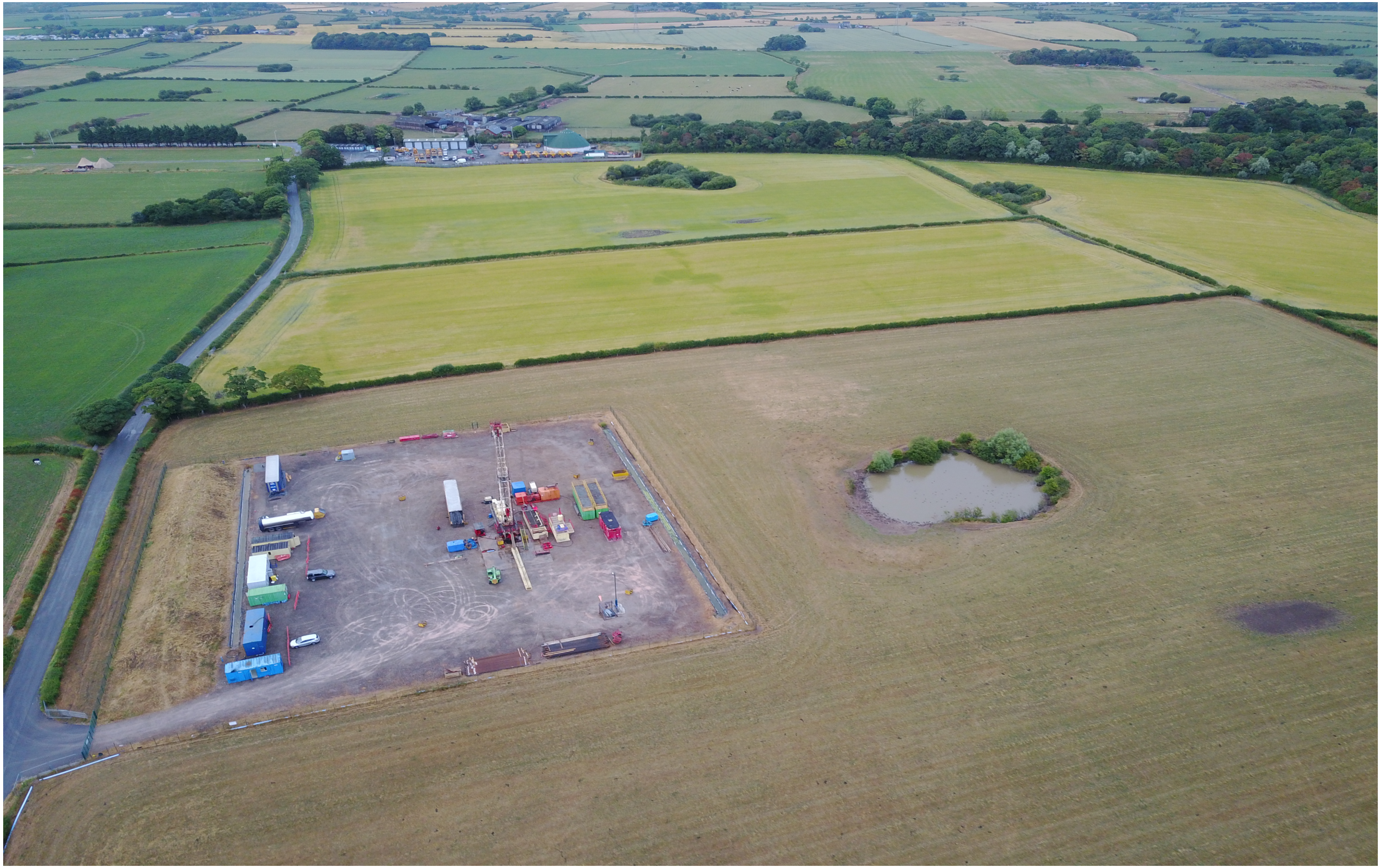

Figure 15: Workover operations on 16 July 2018. A spatially organised moisture or vegetation pattern is visible east of the site, comprising two oval features in the upper field and an elongated expression extending towards the hedge line and the pond immediately adjacent to the wellsite. (The same field is shown under winter conditions in Figure 36 and corresponds with Location C in the LiDAR differencing, Figures 33 and 36.) The imagery establishes alignment and continuity of surface expression, but does not determine the mechanism responsible.

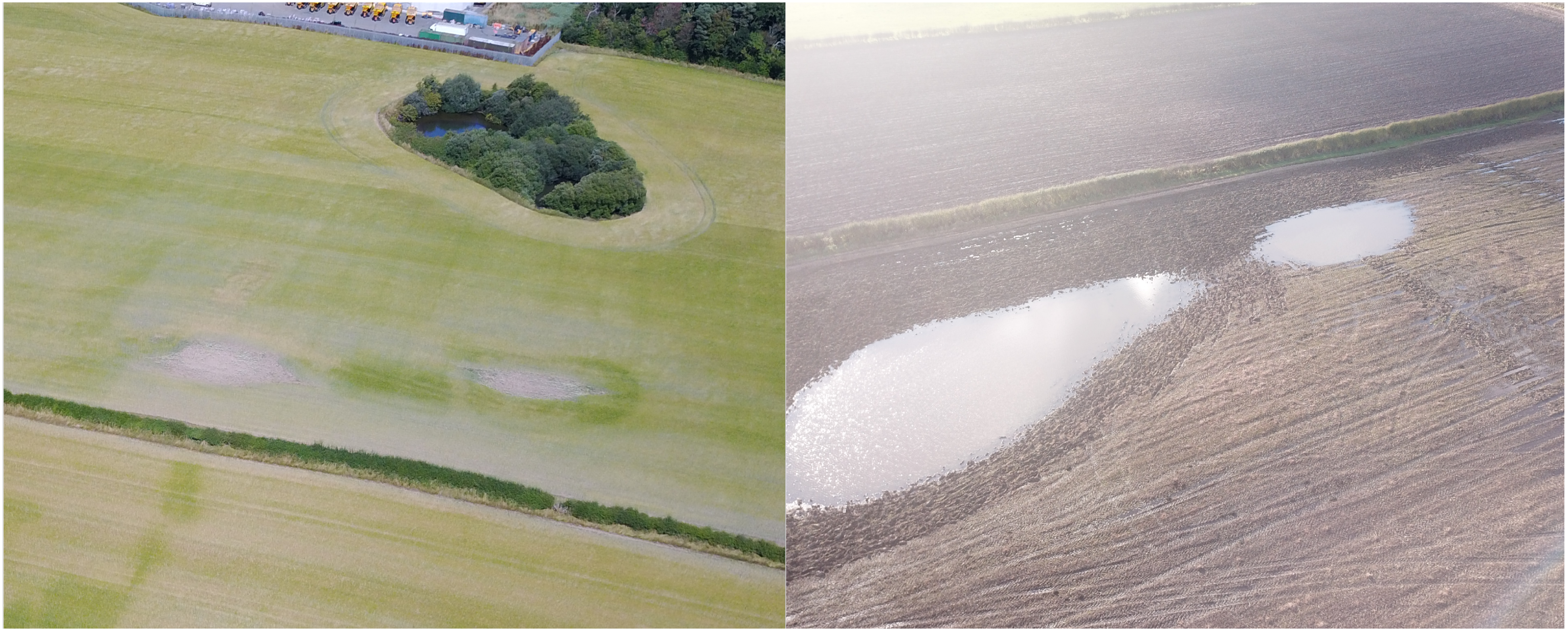

Figure 16: Comparison of the field east of the wellsite under different surface conditions. On 19 July 2018 (left), two oval areas of contrasting vegetation and surface tone are visible near the field boundary. On 27 October 2017 (right), two standing-water features occupy broadly corresponding positions on the cultivated surface. The images were acquired from different viewpoints and are not geometrically registered, but the paired form, relative position and surrounding field expression are consistent across both observations. The marked change in tone between 16 and 19 July 2018 is noted but remains unexplained.

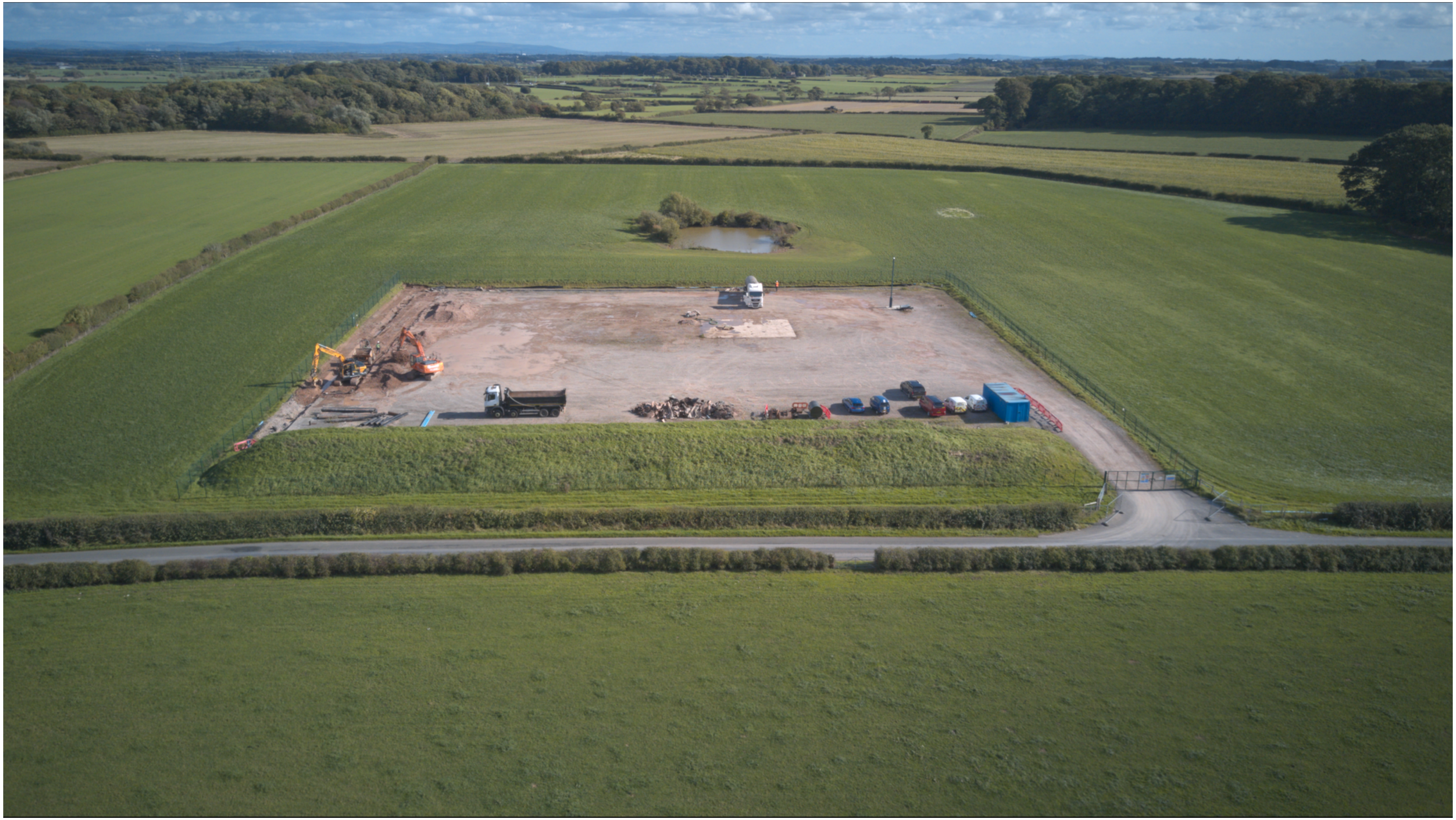

Figure 17: (DNG-derived image) Decommissioning works underway on 12 September 2018. Standing water and wet surface material are visible across the eastern side of the pad, with several pathways converging towards the active excavation area.

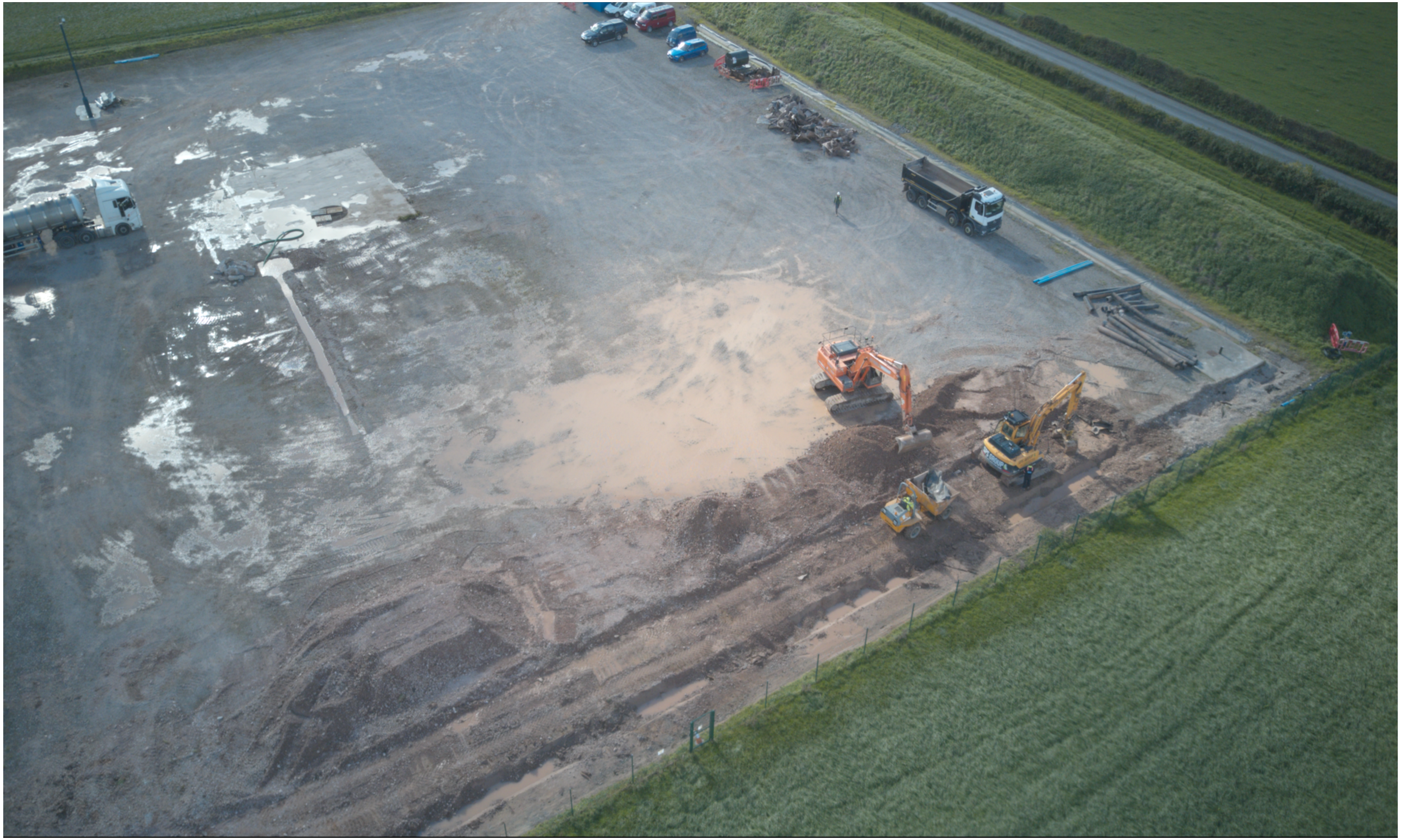

Figure 18: (DNG-derived image) Removal of surface materials along the north-eastern side of the pad has exposed a trench containing standing water and wet sediment. A distinct linear moisture pathway extends across the pad from the vicinity of the well cellar towards the excavated area.

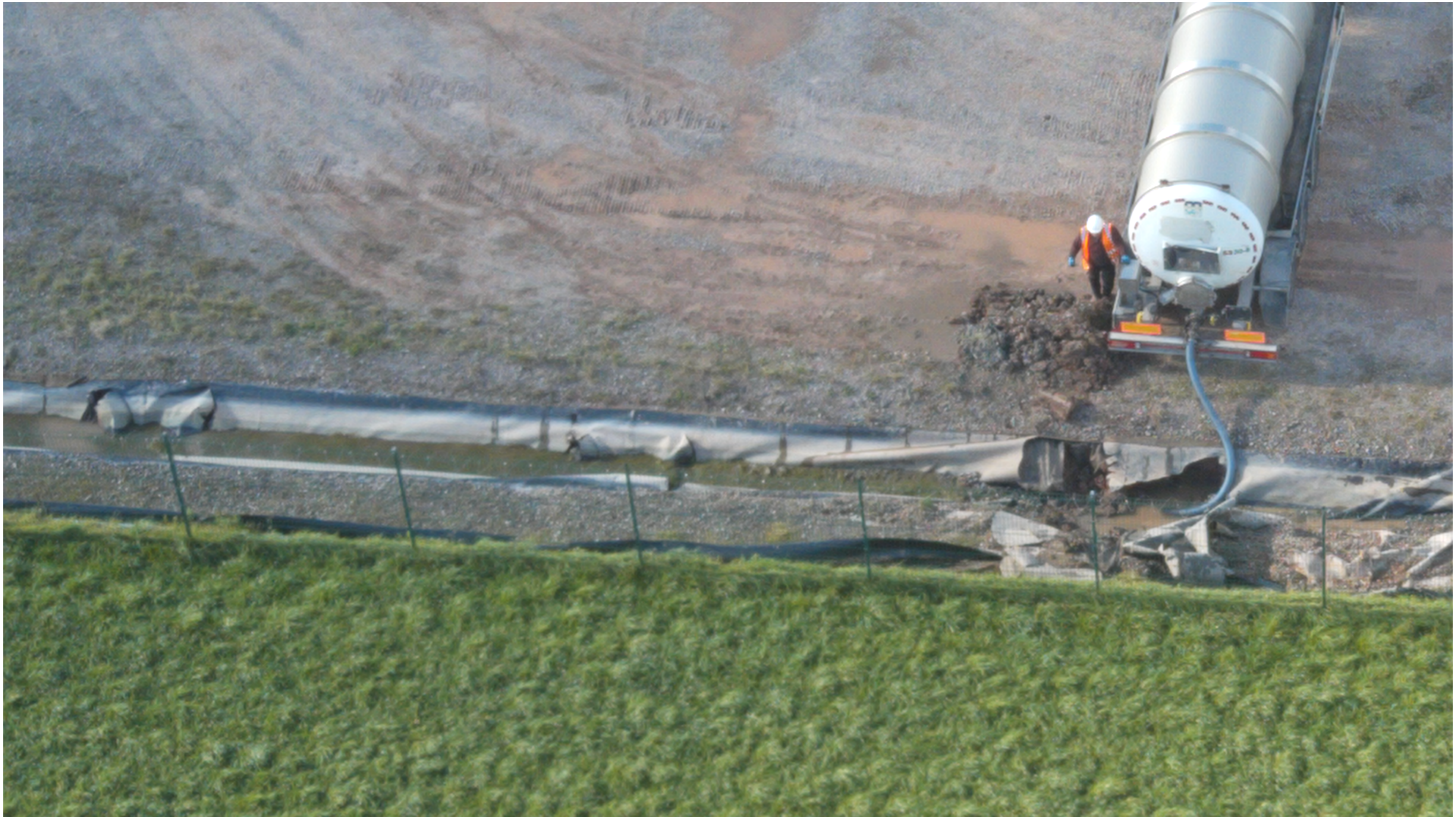

Figure 19: (DNG-derived image) The perimeter ditch has been locally excavated. A tanker is positioned beside the opening, with a hose extending into the excavation. Folds, separations and displaced sections are visible along the exposed liner. White staining is present on parts of the liner previously below the ditch-water level.

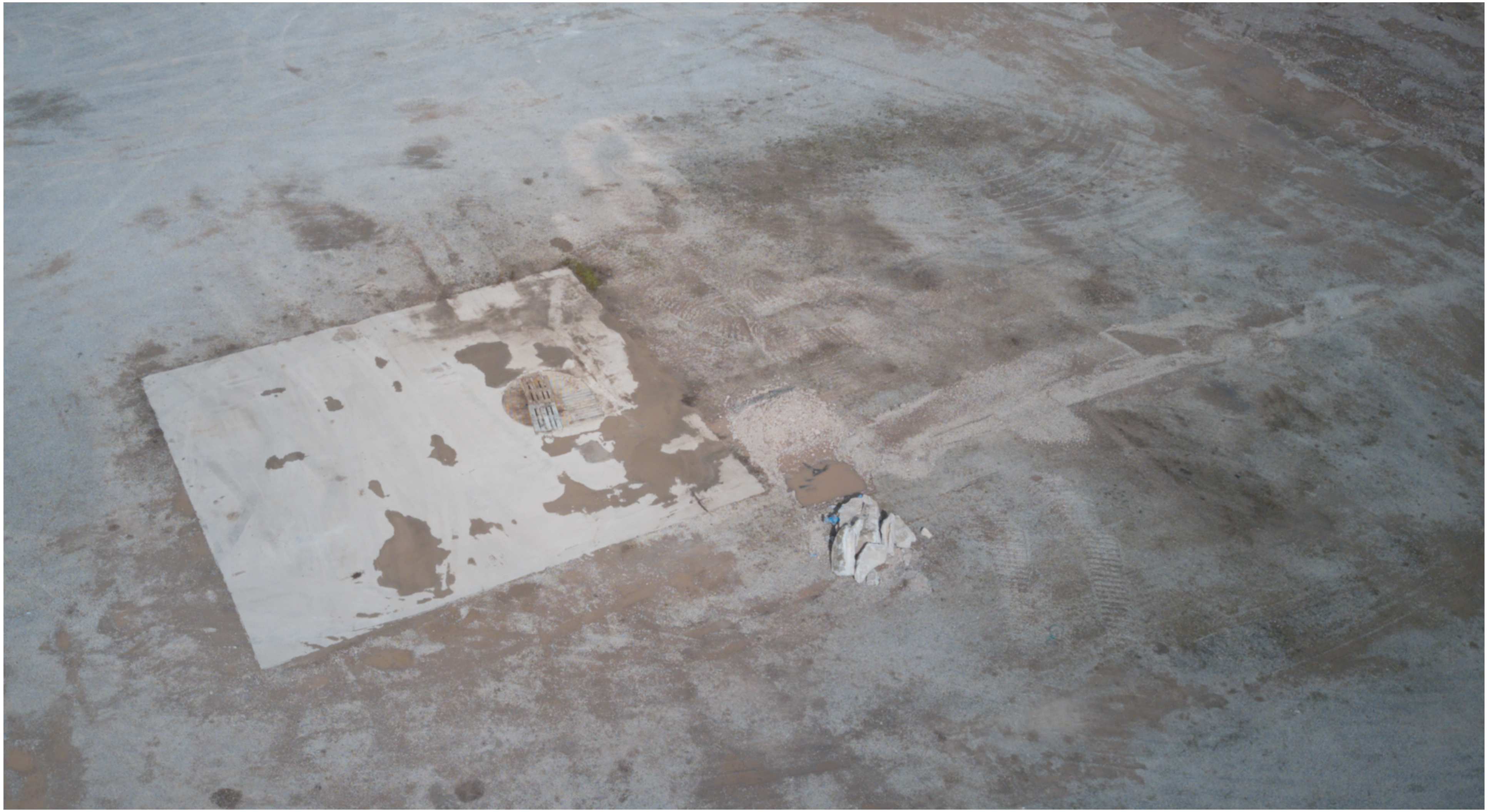

Figure 20: (DNG-derived image) On 13 September 2018, standing water remains visible within part of the well cellar and across adjacent sections of the pad surface. Residual moisture pathways and localised sediment deposits remain discernible around the central pad area following the wetter conditions documented in the preceding surveys.

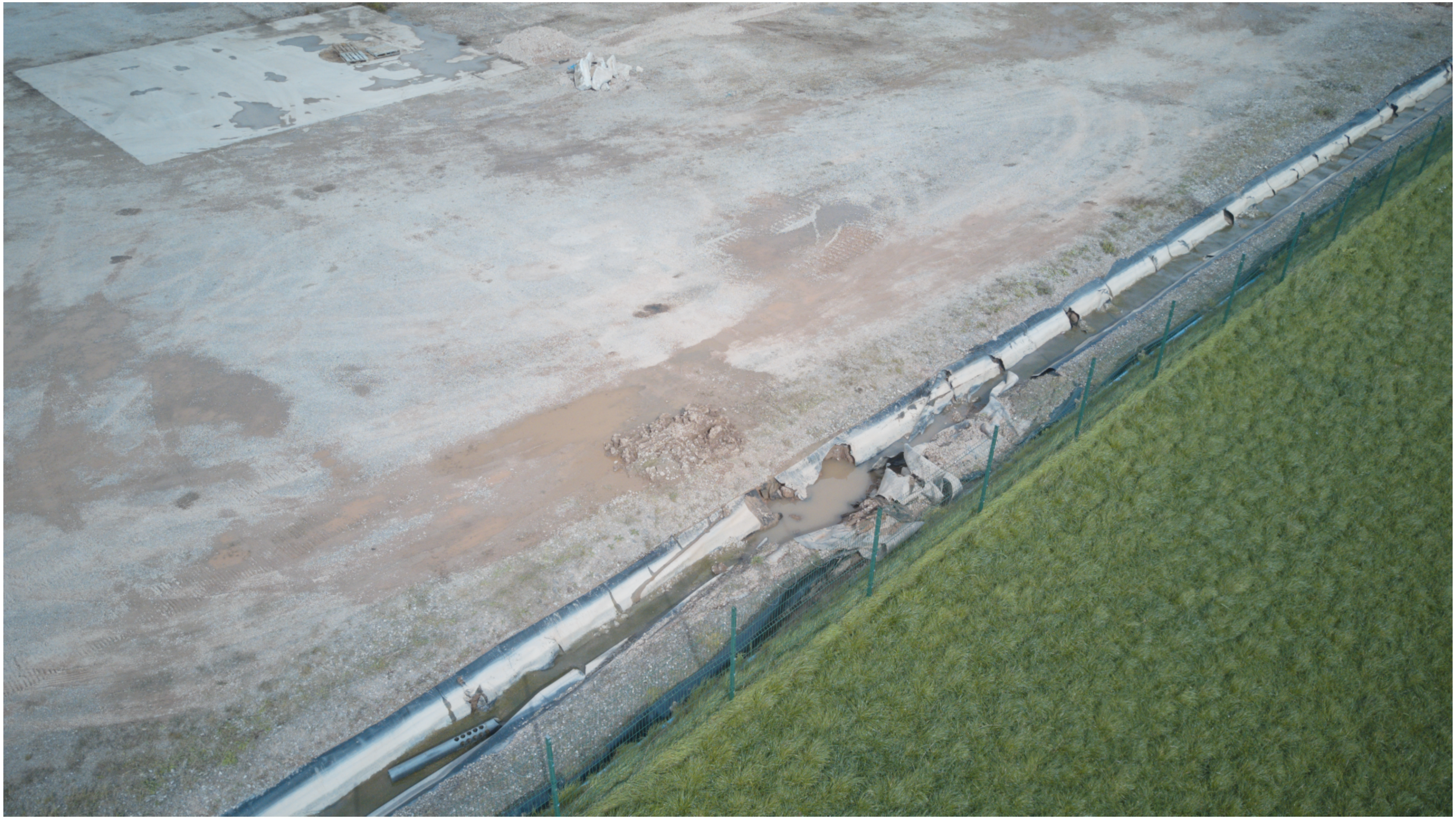

Figure 21: (DNG-derived image) Standing water is retained within the perimeter channel. The exposed liner displays repeated folds, breaks, separations and displaced sections along its length.

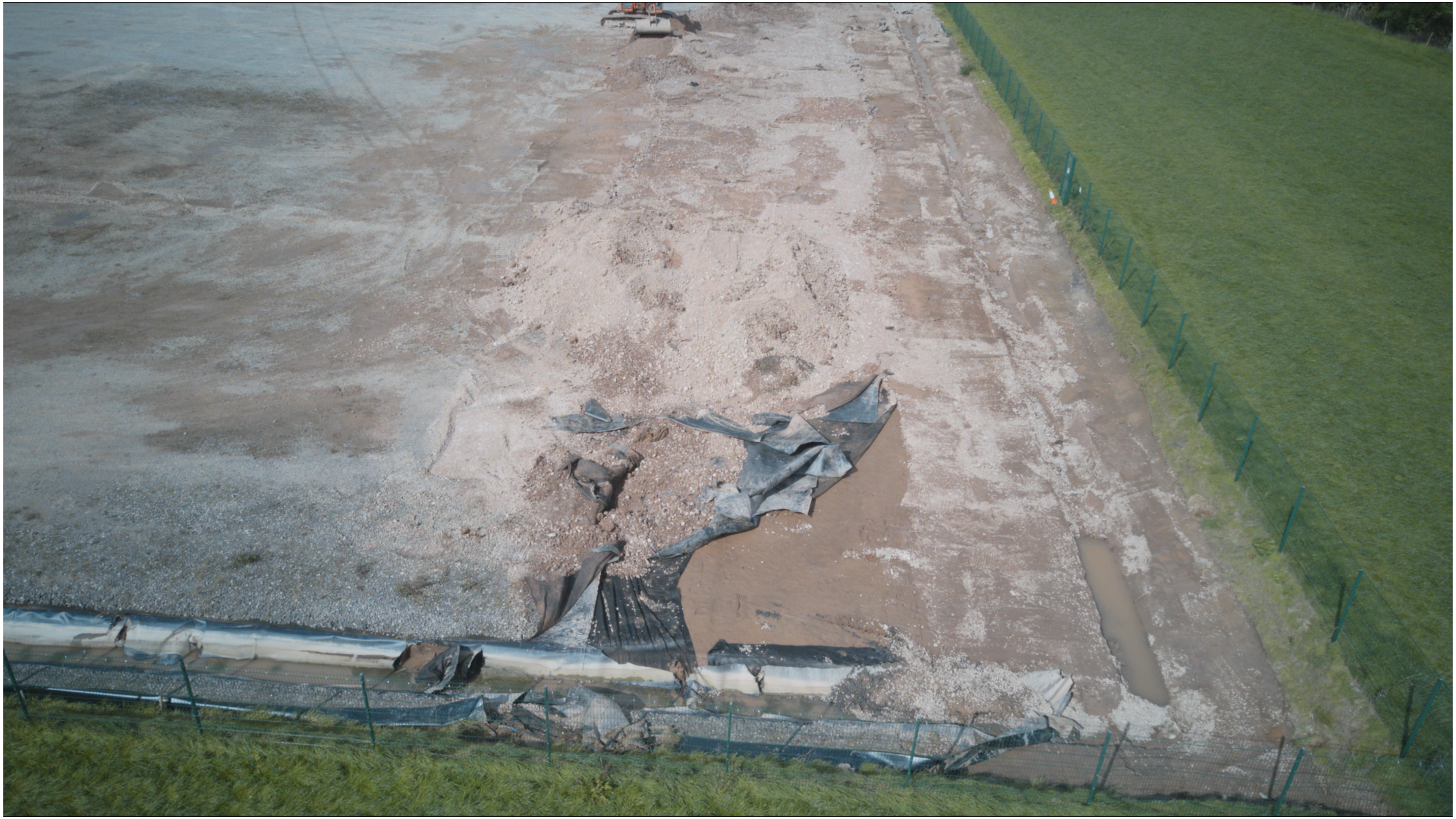

Figure 22: (DNG-derived image) Surface layers have been stripped from the eastern edge of the pad, exposing construction materials and sections of folded and displaced membrane. The surface below the membrane is moist. Muddy water and wet material are visible within and adjacent to the excavated area.

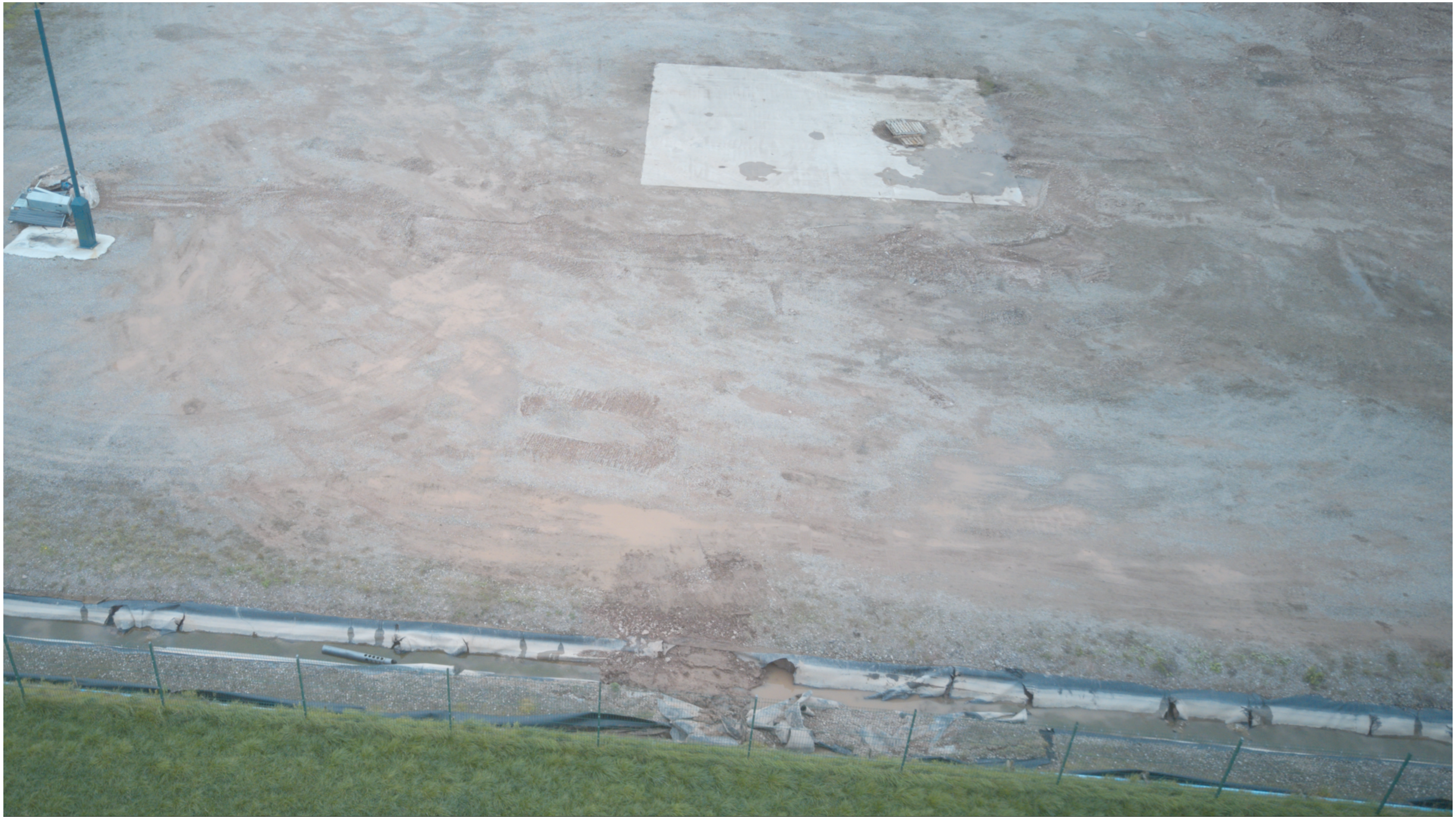

Figure 23: (DNG-derived image) By 14 September, excavated material had been replaced across the previously opened section of the perimeter ditch, covering much of the liner and underlying material visible during the preceding survey. The section shown opened and accessible in the previous survey is, in this image, backfilled; material visible at the surface one day earlier is no longer exposed for observation or sampling.

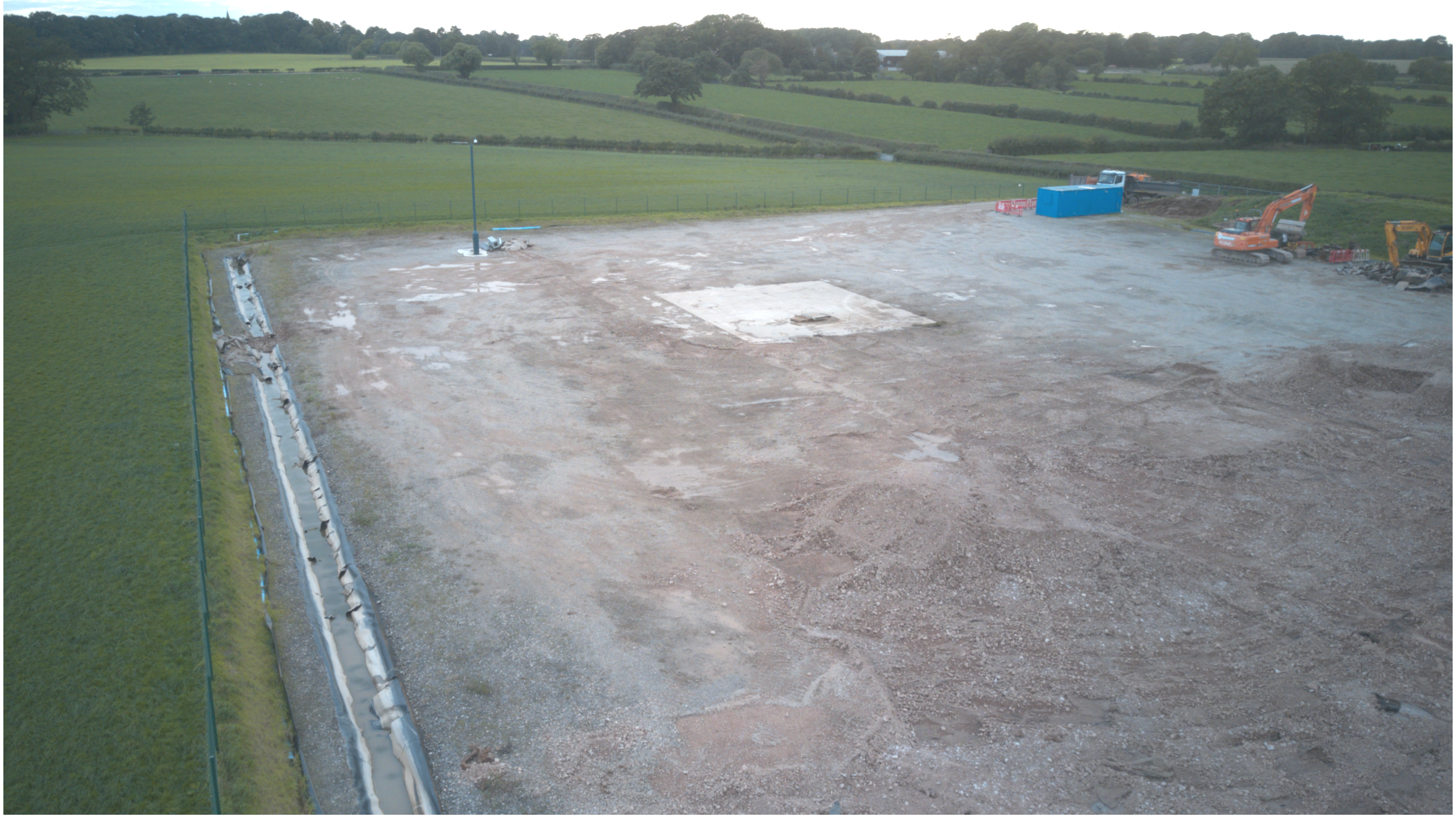

Figure 24: (DNG-derived image) The disturbed gravel displays a broadly distributed reddish-brown tonality. Surface-water pathways and damp areas differ from those visible during the preceding surveys, while standing water remains present within sections of the damaged perimeter ditch.

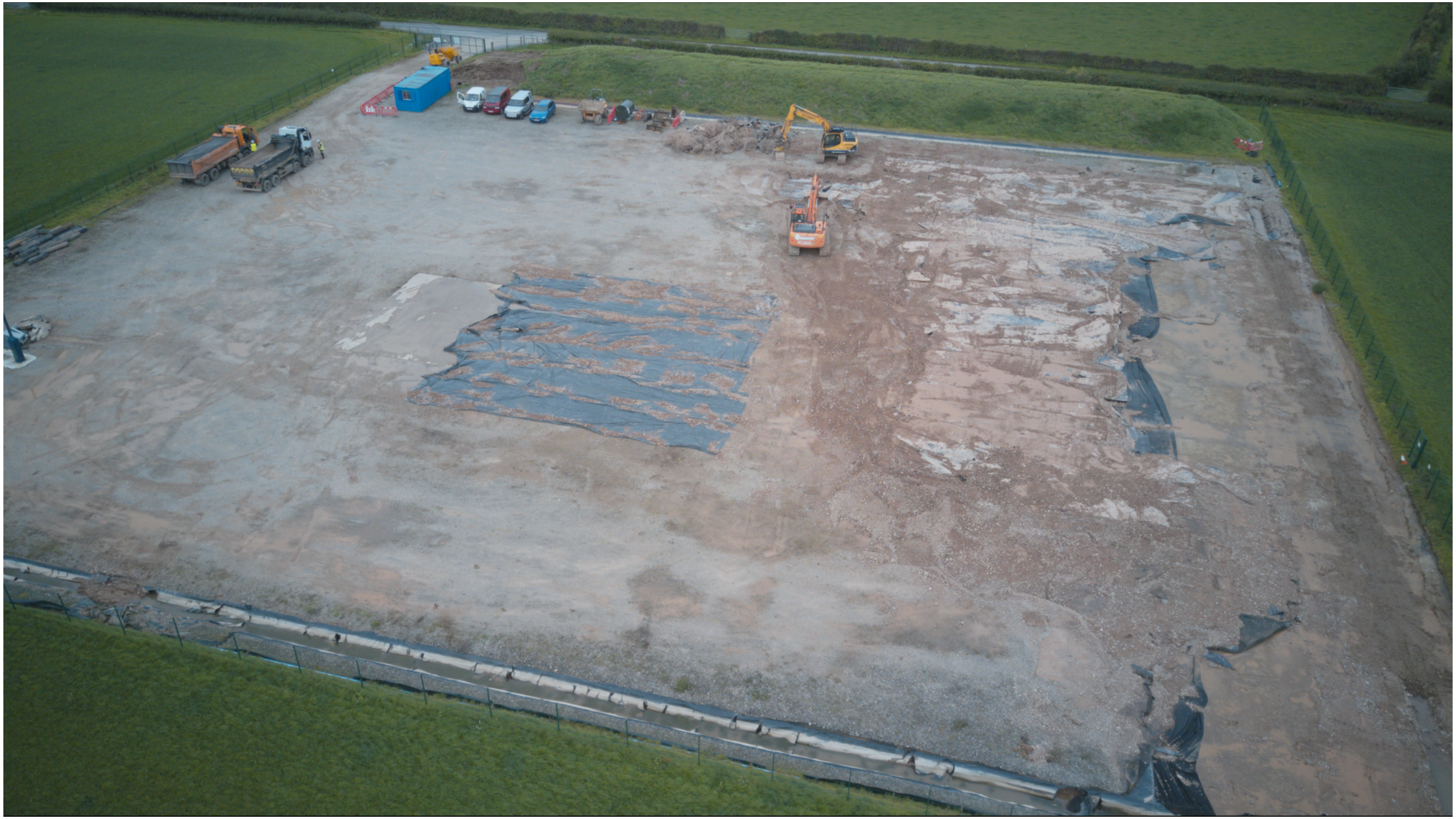

Figure 25: (DNG-derived image) Oblique aerial overview during surface removal, showing exposed subgrade, retained and displaced membrane sections, machinery access routes, and localised wet ground along the eastern and south-eastern margins.

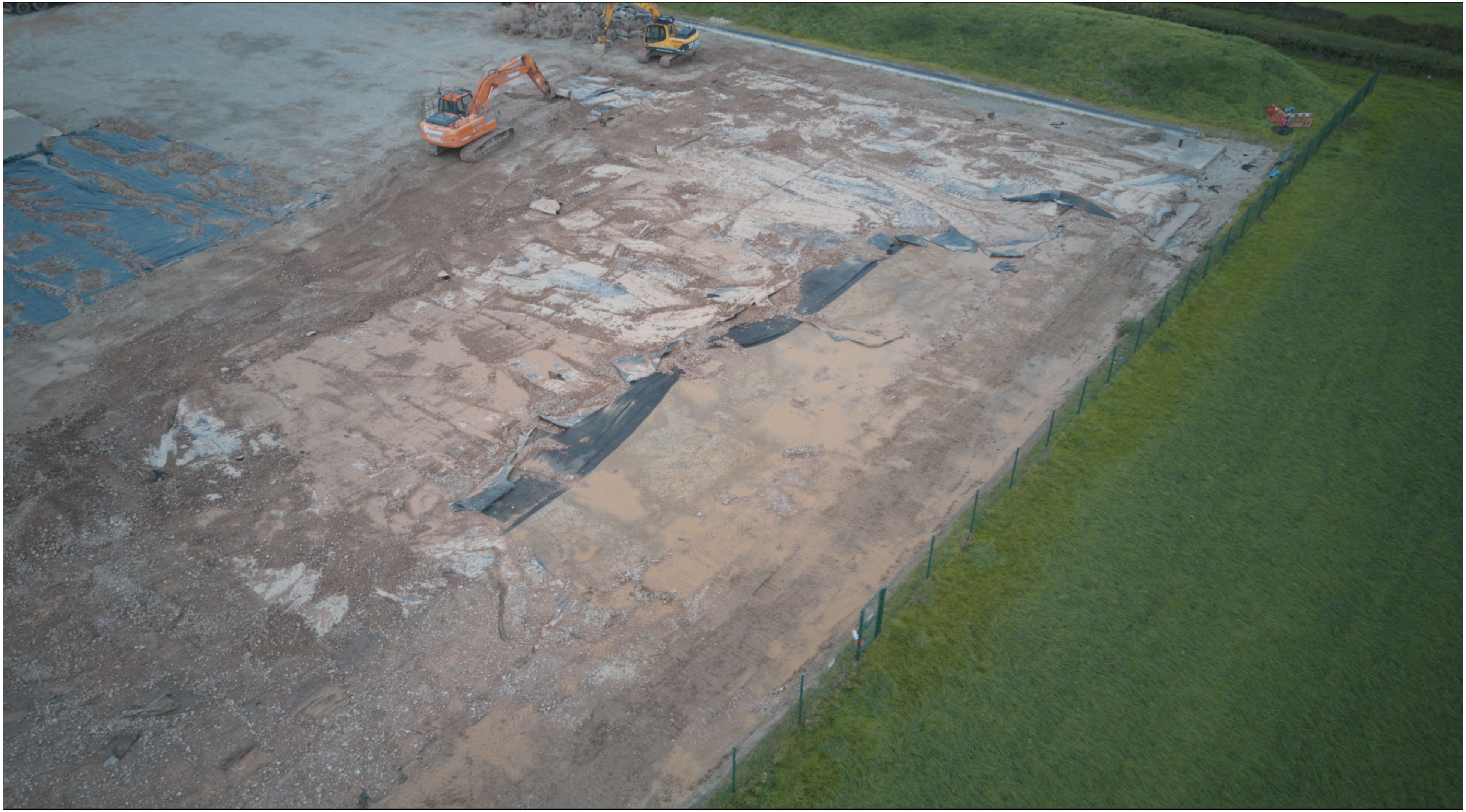

Figure 26: (DNG-derived image) The exposed eastern subgrade is extensively wet, with standing muddy water and channel-like surface forms visible beneath displaced sections of membrane. These features are distributed across the opened area rather than confined to a single isolated puddle. Vegetation variation is also visible within the adjoining field.

4. Post-Restoration Observations

Repeat aerial surveys were undertaken in 2019 and 2026 after removal of the former wellsite infrastructure and return of the land to agricultural use. These surveys provide a basis for examining whether features associated with the earlier site configuration remained identifiable after restoration.

The post-restoration imagery is assessed comparatively against the operational and decommissioning record presented in the preceding section. Attention is given to recurring differences in vegetation, moisture expression, surface tone and spatial geometry rather than to isolated colour variation within individual images.

The former drainage alignment remains detectable several years after its visible removal through recurring vegetation and moisture differentiation. Other parts of the former site footprint and surrounding landscape also retain spatial expressions that correspond with features recorded before or during restoration.

No attempt is made here to determine mechanism. Such persistence may reflect disturbed soil, trench backfill, differential compaction, altered drainage, agricultural management, seasonal conditions or combinations of these factors. The observation is more limited: elements of the former engineered landscape remain empirically legible after the infrastructure itself has disappeared.

The following figures document that post-restoration persistence and provide the photographic context for comparison with the 2018–2022 LiDAR elevation-differencing results presented in Section 5.

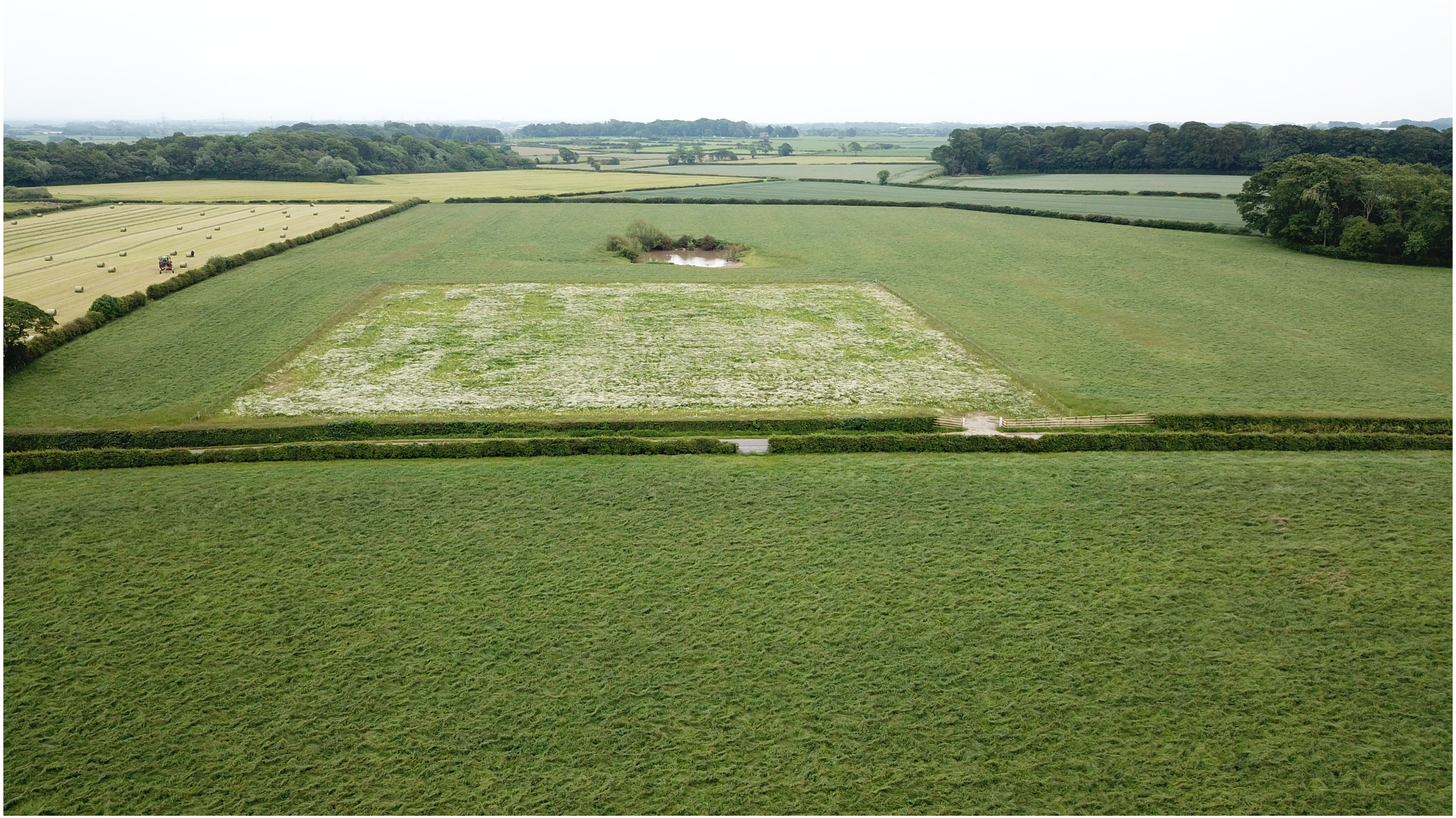

Figure 27: Overview of the former wellsite footprint on 7 June 2019. The fenced area is occupied by a visually distinct cover of white-flowering vegetation, sharply differentiated from the surrounding pasture. Within the former site boundary, the vegetation is distributed in bands, lobes and intervening sparsely covered areas that appear to reproduce elements of the spatial structure previously expressed by staining, wetness and exposed substrate during dismantling. The correspondence is observational rather than causal, but the persistence of a comparable internal pattern after restoration is notable. The adjacent pond is visible beyond the northern boundary.

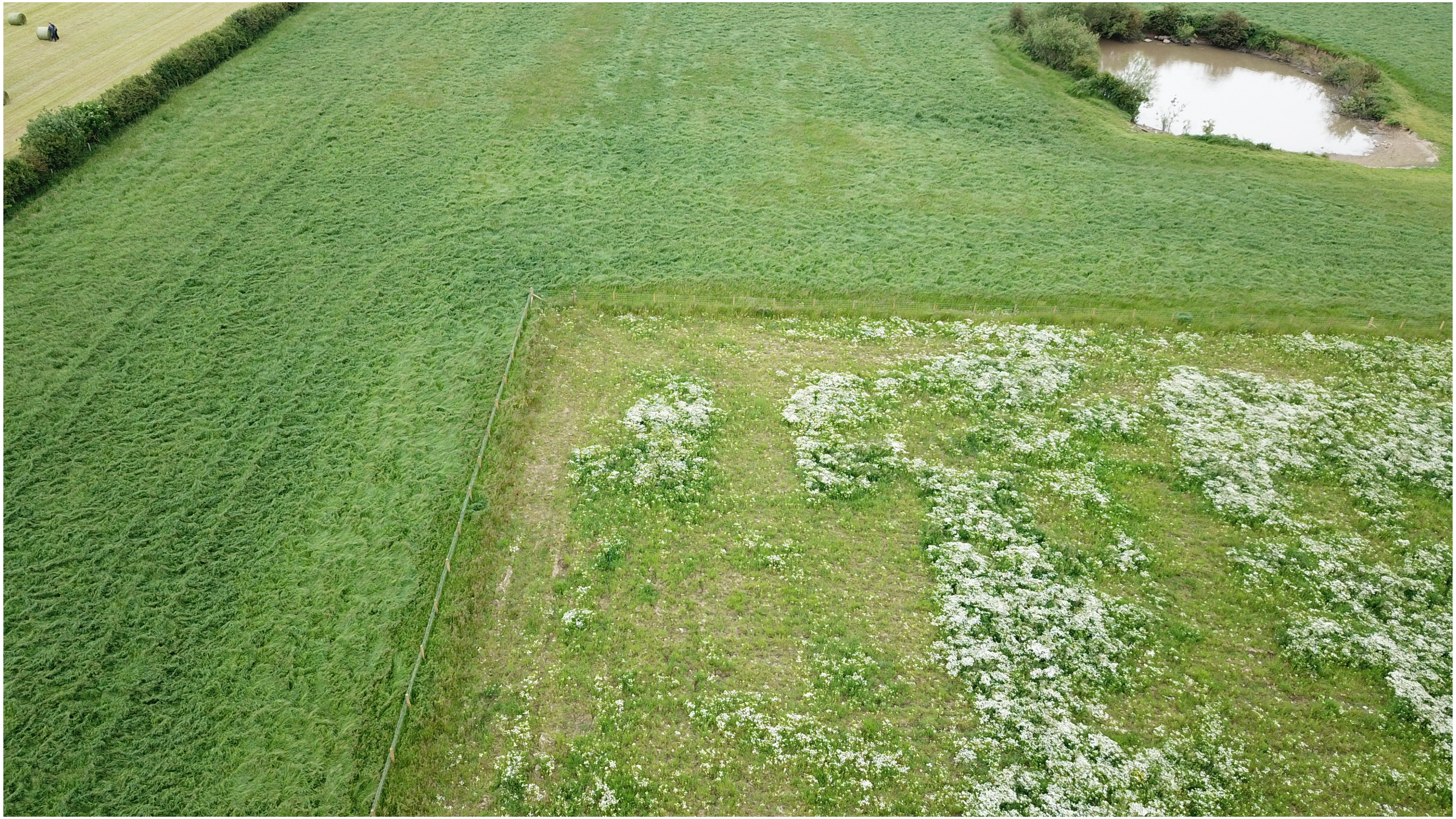

Figure 28: Vegetation patterning within the restored footprint. The wider view shows the distribution of white-flowering vegetation within the fenced former site, including broad curved, lobate and branching forms that are not expressed uniformly across the surrounding fields.

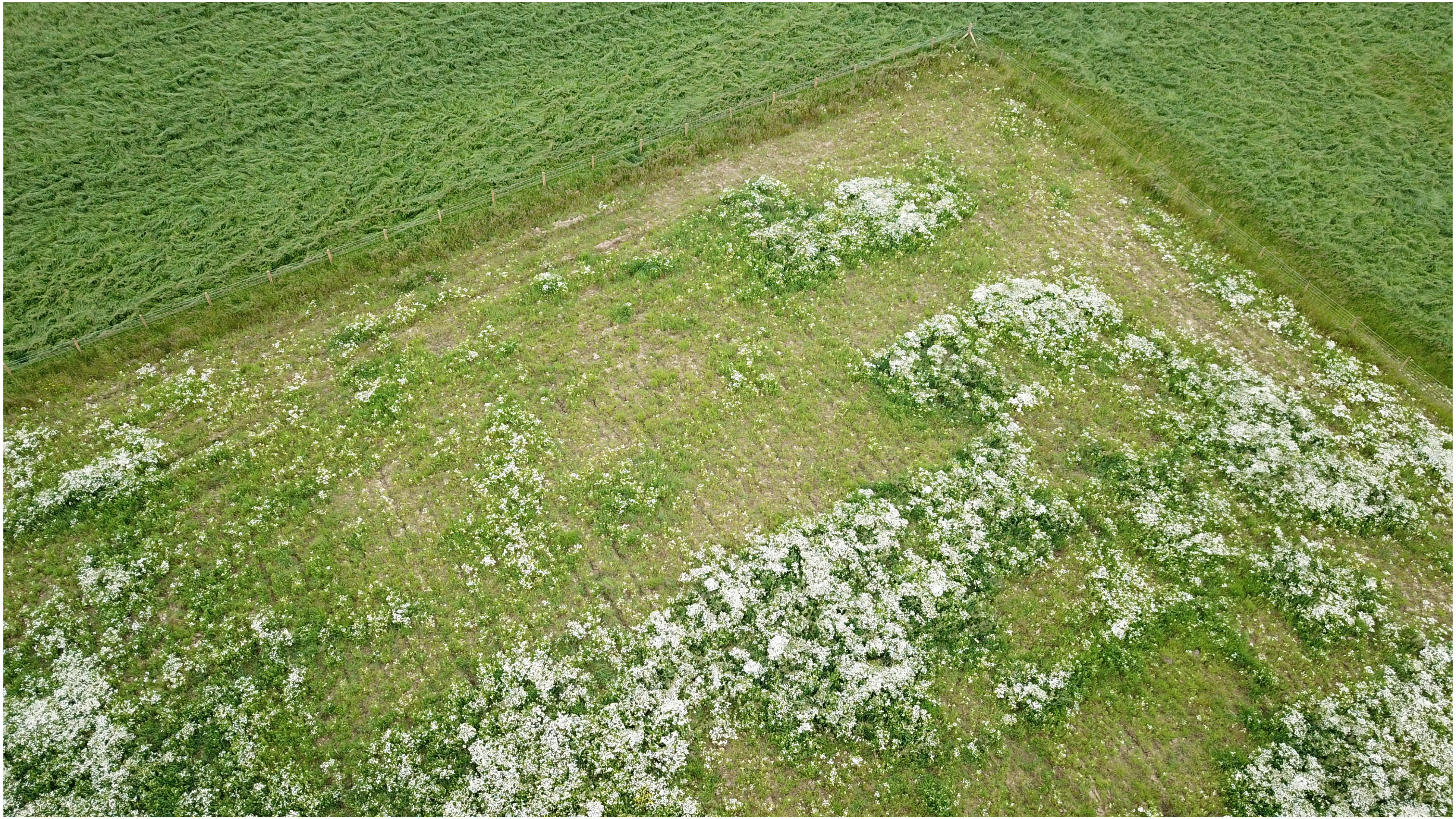

Figure 29: The closer view demonstrates the internal structure of these forms, comprising dense bands separated by areas of thinner or absent cover. Their spatial arrangement resembles elements of the staining, wetness and substrate patterning recorded during dismantling.

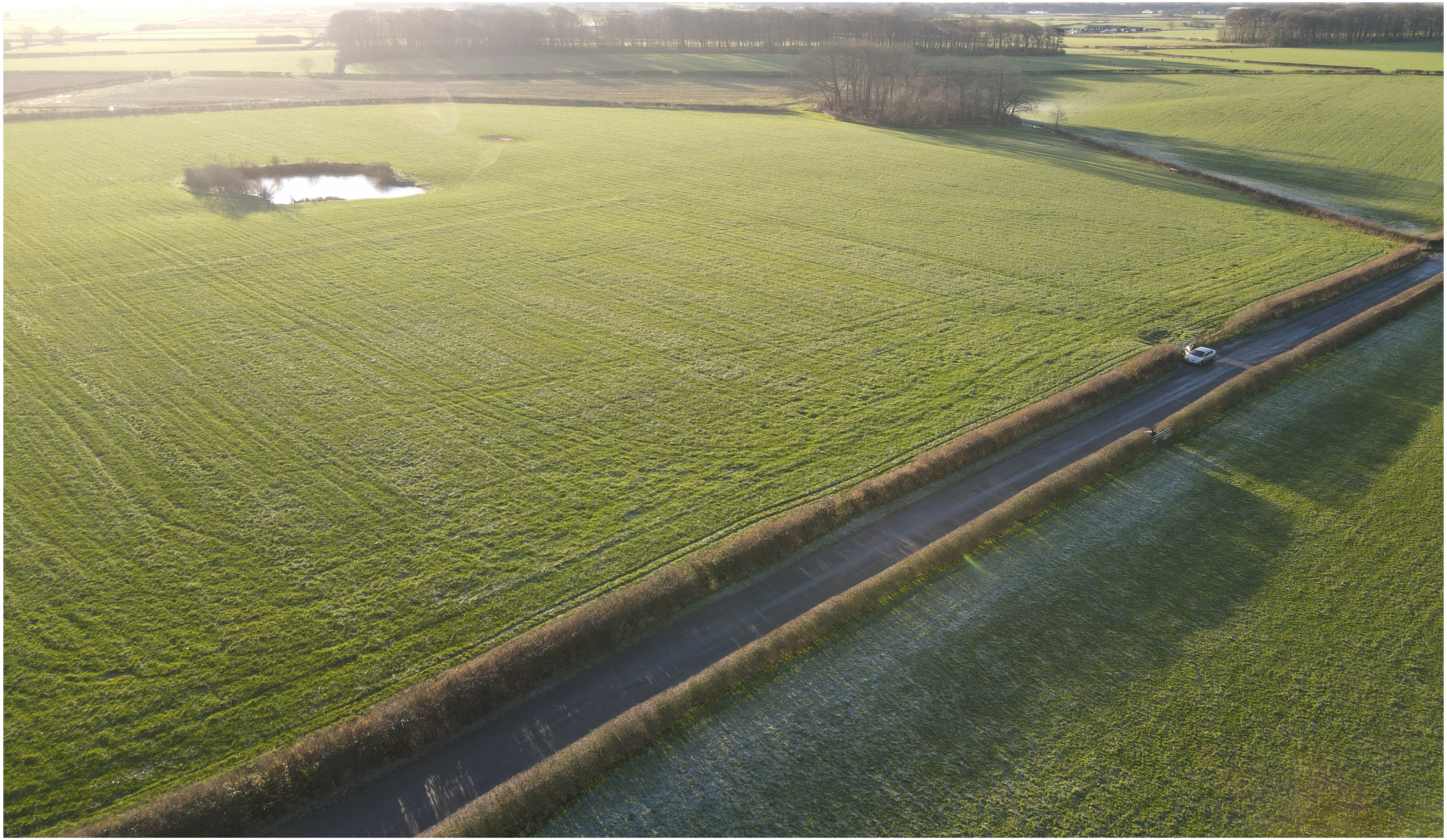

Figure 30: Wider view of the field showing broad, spatially organised variation in vegetation tone and texture. Curving and linear darker bands extend across the field, with a distinct discoloured patch visible beyond the pond. The pattern is not uniformly distributed and appears to follow a persistent internal structure within the field.

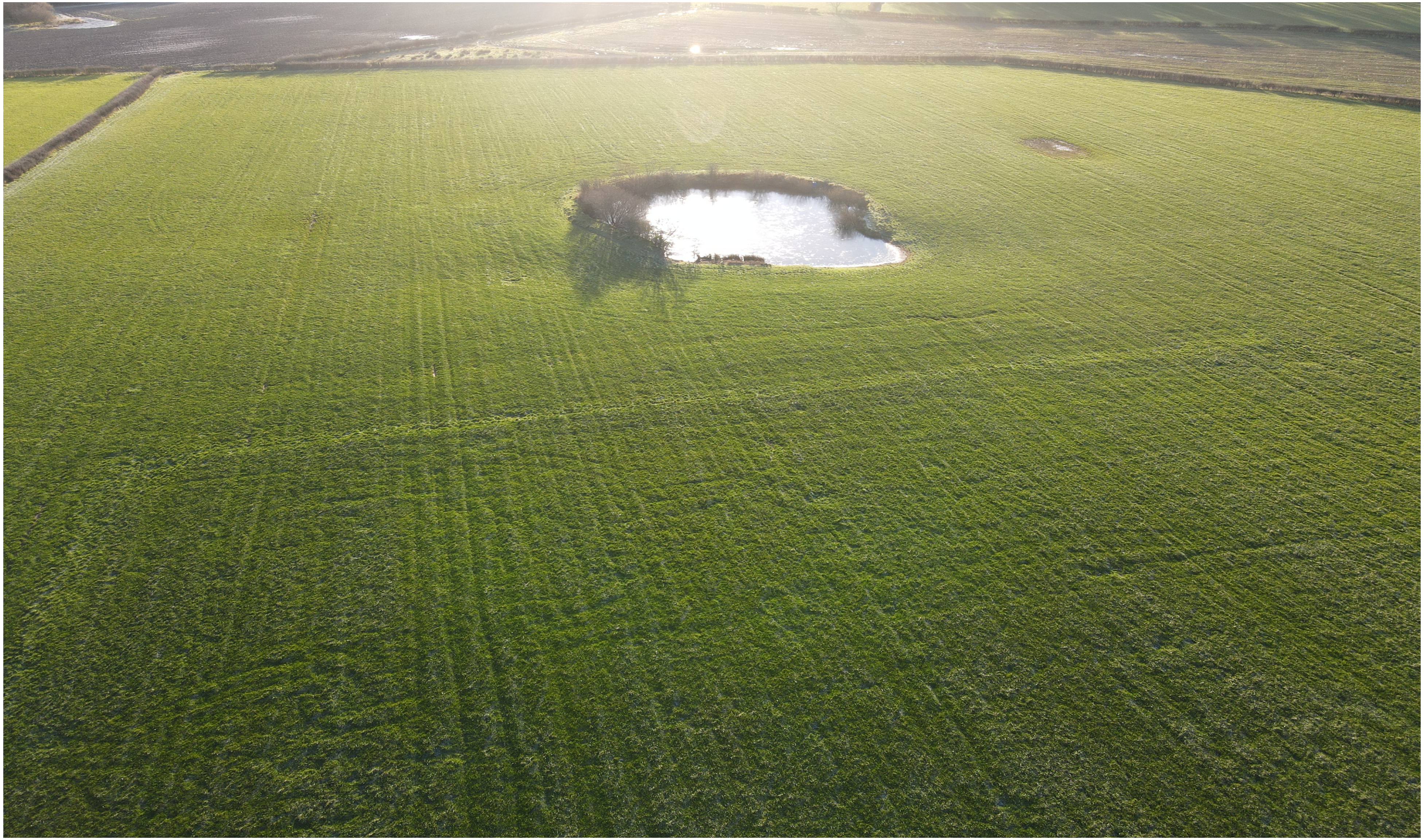

Figure 31: Closer view of the same field pattern. Intersecting linear and curvilinear bands are visible, together with localised areas of contrasting vegetation response. A linear band exhibiting distinct vegetation patterning crosses the middle of the image at the position of the former drainage alignment. These forms resemble drainage, wetness and substrate patterns documented during earlier phases of site disturbance and dismantling. Their cause is not established, but their spatial persistence is notable.

5. LiDAR Differential 2018 – 2022

Environment Agency National LiDAR Programme data acquired in 2018 and 2022 were used to examine measurable surface-elevation change across the former Grange Hill site and surrounding agricultural landscape. These data form part of the same regional elevation-differencing dataset used in related assessments of the Fylde coastal plain.

The available point-cloud data for each survey year were merged and rasterised to a common one-metre grid in OSGB36 / British National Grid coordinates. The 2018 elevation surface was then subtracted from the 2022 surface:

$\Delta z = \text{elevation2022} - \text{elevation2018}$

Under this convention, negative values represent relative surface lowering between the two survey epochs, while positive values represent relative elevation gain. Values close to zero indicate comparatively limited measured change.

Differential LiDAR is sensitive to differences in acquisition geometry between epochs as well as to genuine ground-level change. Survey swath direction, flight-line overlap, scan angle and point density all influence the elevation surface a given survey resolves, and systematic differences between the 2018 and 2022 acquisitions can introduce apparent elevation change along flight-line and tile boundaries that does not correspond to any physical alteration of the ground. Such artefacts characteristically express as linear or rectilinear features aligned with the survey geometry rather than with landscape features. The differential surface presented here contains one such boundary, visible as a tonal transition crossing the wider scene; it is identified here so that it is not mistaken for ground change. The elevation features discussed below lie within continuous data internal to a single tile and are not coincident with this boundary, and their geometry aligns with landscape and former-site features rather than with the survey grid. They are therefore retained as candidates for comparison while the flight-line boundary itself is excluded from interpretation.

The resulting differential surface was examined using colour-relief rendering, hillshade and fine-interval contours. These visualisations serve different but complementary purposes. Colour relief shows the broad spatial distribution and relative magnitude of elevation change; hillshade assists recognition of subtle surface form; and contours make the geometry of local elevation differences more explicit.

Three areas were selected for closer presentation because their elevation-derived form corresponds spatially with features independently visible in the aerial and UAV record. Contemporary images acquired in 2026 are placed immediately after the LiDAR data to show the present-day surface condition at, or close to, the identified locations.

The analysis is comparative rather than diagnostic. Elevation differences may reflect multiple influences, including agricultural activity, vegetation, drainage works, soil movement, water pathways, survey conditions and genuine ground-level change. The LiDAR data are therefore not used independently to determine mechanism or causation. Their role is to test whether features identified visually in the photographic chronology also possess measurable spatial expression within an independent elevation dataset.

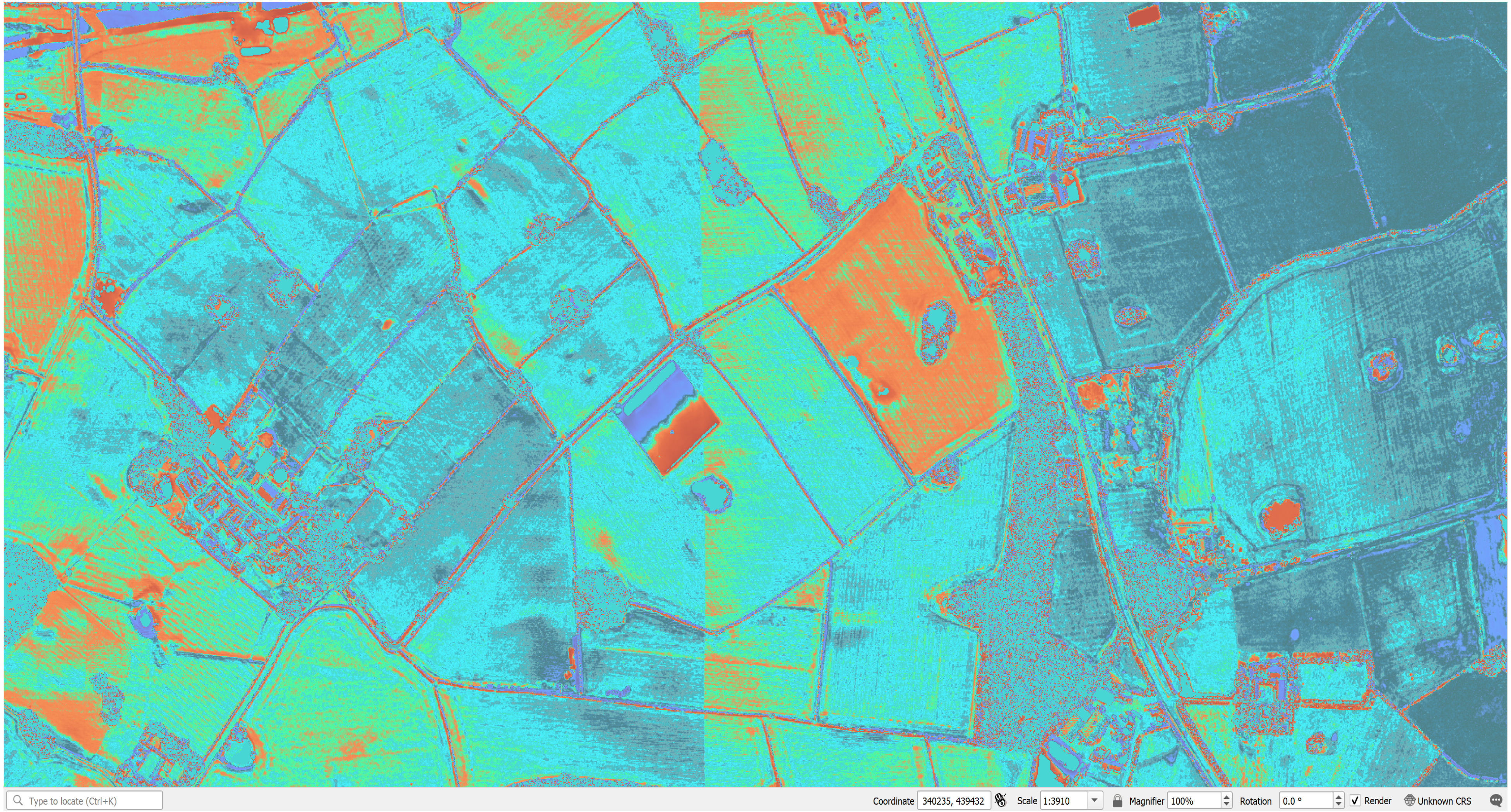

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Figure 32: LiDAR elevation differencing between 2018 and 2022 showing marked internal variation across the former wellsite and surrounding agricultural land. The restored pad exhibits a sharp transition from relative lowering across much of its north-western half to relative elevation gain across the south-eastern half, broadly aligned with the former well installation. An oval no-data or anomalous-return area near the roadside margin corresponds with the location of the soil mound along this margin. Darker areas of relative lowering within the north-western part of the pad also align spatially with lower-value features in the field on the opposite side of the road. These patterns are presented as features requiring comparison rather than as evidence of a specific mechanism.

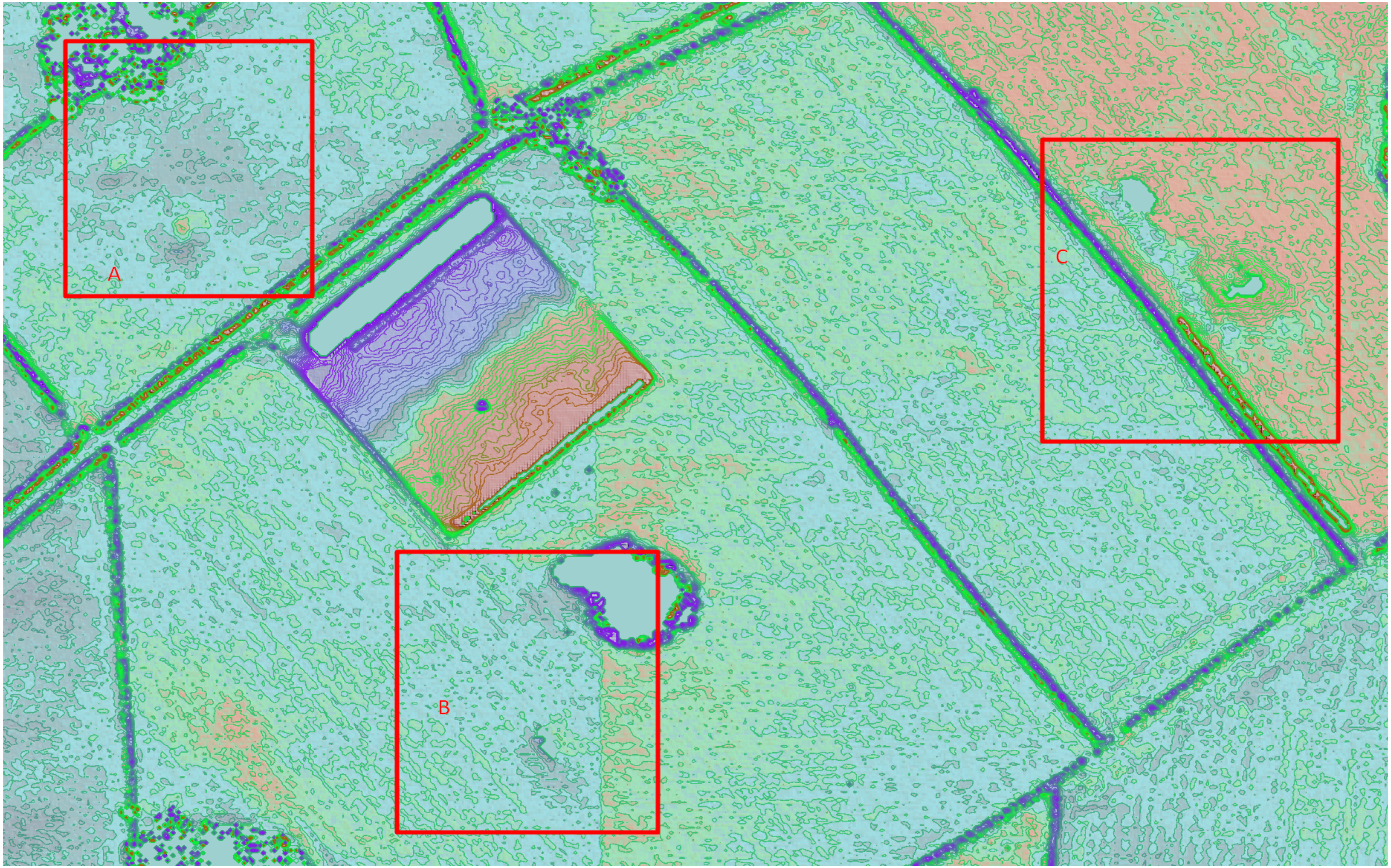

Figure 33: Contour rendering of the 2018–2022 elevation-difference surface highlighting three locations selected for closer examination, labelled A to C. Each contains a lobate area of relative surface lowering that can be compared with the January 2026 imagery presented in the following figures.

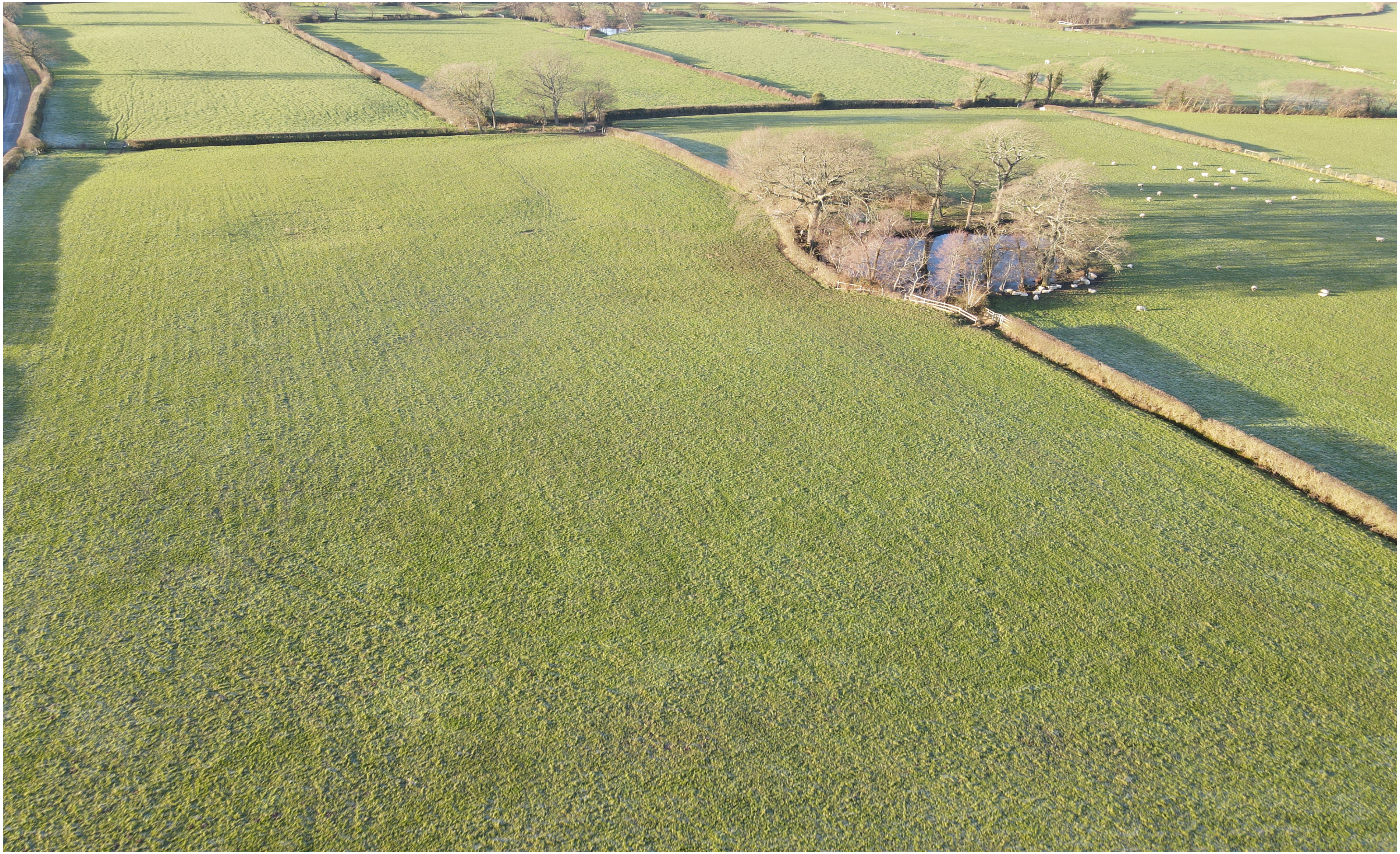

Figure 34: January 2026, Location A. A localised area of uneven or depressed ground is visible within the field at the location identified in the LiDAR elevation-difference surface.

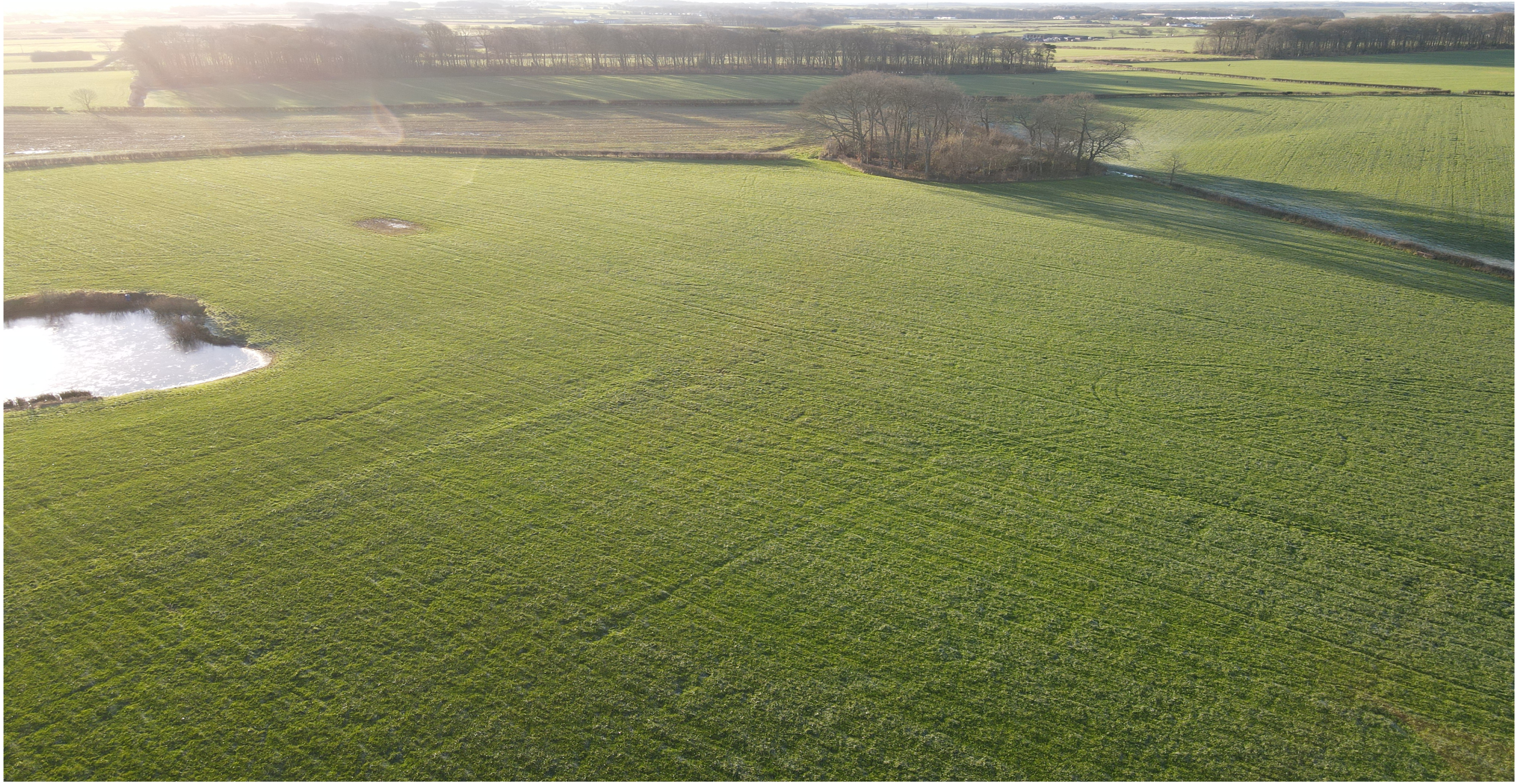

Figure 35: January 2026, Location B. The pond margin and adjoining ground show localised surface variation. An oval feature in the field beyond corresponds spatially with an area of approximately 5–10 cm relative lowering in the LiDAR elevation-difference surface.

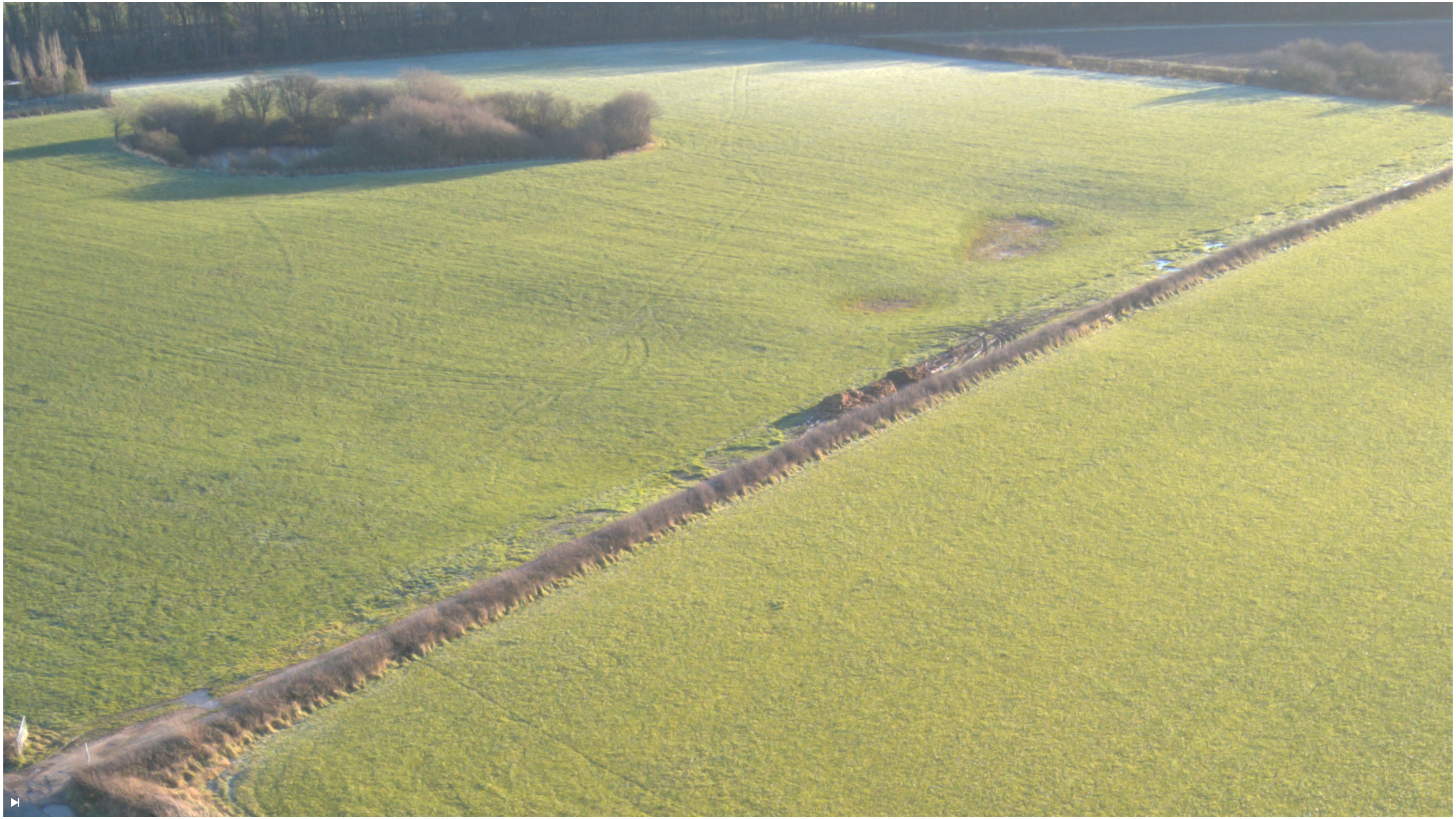

Figure 36: (DNG-derived image) January 2026, Location C. Mottled vegetation and areas of disturbed or exposed soil are visible east of the former site within the location identified from LiDAR differencing. (Compare with Figure 15, the same field during workover operations in July 2018.)

6. Discussion

6.1 The asymmetry of erasure

The central feature of the Grange Hill record is not any individual observation but the order in which the relevant processes occur. Restoration is, by design, irreversible: excavation, removal of hardstanding and membrane, regrading, soil replacement and cultivation each permanently alter the surface and shallow subsurface through which earlier conditions could otherwise be examined. Verification capable of establishing physical, hydrological and material recovery is, by contrast, not shown in the records presently assembled, and may not occur before restoration alters the conditions available for examination.

These processes may therefore act on the same ground in an evidentially adverse sequence. The only period in which the pre-restoration condition of the site can be directly characterised is the period before that condition is removed. Where additional characterisation depends upon a concern first being formally recognised, restoration may alter the evidence from which that concern could have been substantiated – so that the moment at which evidence could be secured is also the moment at which the basis for securing it is weakest.

This is not a claim about intent. It is a structural observation. Where characterisation is conditional on prior suspicion, and where the act of restoration may remove or materially weaken the evidential basis on which the condition could later be assessed, the tendency is toward restored sites that are formally complete and evidentially silent at the same time. Grange Hill is presented here as a worked example of that asymmetry rather than as an allegation arising from it.

6.2 Persistence and the limits of the ordinary explanation

The persistence documented here may have an ordinary explanation. The former site comprised engineered and compacted ground, and such ground may reasonably be expected to drain, retain moisture and support vegetation differently from the surrounding fields. On this view the recurring footprint, the former drainage alignment and the differential vegetation are the expected legacy of construction, and not in themselves remarkable.

This explanation is correct in its premise and revealing in its conclusion. If the persistence is the expected consequence of engineered disturbance, then it follows that the surface carries a durable physical record of that disturbance - one that remains legible across season, vegetation state and independent measurement years after the infrastructure was removed. The explanation therefore does not dispute persistence; it concedes it, and supplies a mechanism for it. What it does not supply is any evidence that the persistent condition was defined or measured. "Of course it responds differently" is an explanation offered in place of a measurement, not in addition to one.

The former drainage alignment is the clearest case. Although the visible ditch infrastructure was removed during restoration, its former position remains detectable through recurring vegetation and moisture differentiation in the post-restoration record (Figure 31). This is the least ambiguous example of expected legacy: there is no contamination implication, and the most likely explanations - trench backfill, differential compaction, retained drainage connectivity - are entirely ordinary. Yet it is precisely because the feature is so plainly an expected consequence of construction that its status is instructive. An expected legacy is still a physical condition, and whether it was anticipated, defined and confirmed against a recovery expectation is a question the "expected legacy" reading raises rather than answers.

The distinction matters because the competing readings are not separable from imagery alone. Differential compaction, trench backfill, altered drainage connectivity, redistributed material and ordinary agricultural variation can each produce a persistent surface signature, and several may act together. LiDAR differencing carries its own limitations: apparent elevation change between epochs may be influenced by vegetation height, crop condition, survey timing, point density and interpolation as well as by genuine ground movement, and the flight-line considerations set out in Section 5 apply. The imagery and elevation record together establish that *a* persistent signature exists and recurs at identifiable locations; they cannot establish *which* process produced it. That is why the "compacted ground" explanation, however plausible, cannot be accepted as a finding rather than an assumption. It describes what may have happened. It does not record what was measured.

6.3 Convergence across independent datasets

No individual image, area of staining or elevation feature is diagnostic. The evidential weight of the record arises instead from correspondence between observations acquired at different times, in different seasons and through different methods.

The field east of the former pad illustrates this directly. Paired oval features are visible as standing water on cultivated ground in October 2017 (Figure 16), and as tonal and vegetation expressions in July 2018 including in the background of Figure 15. The same ground appears as wet and disturbed mottling under low winter sward in January 2026 (Figure 36), and as an apparent elevation difference within the 2018–2022 LiDAR comparison (Location C, Figures 33 and 36).

These datasets do not measure the same property. Photography records reflected light, colour, surface condition and vegetation; LiDAR differencing records apparent change in surface elevation between epochs. Spatial correspondence between them therefore does not prove a common cause. It does, however, identify locations where a feature recurs across method and season, and such locations are stronger candidates for investigation than any single dataset could justify alone. The appropriate interpretation is corroborative spatial coherence, not causal confirmation.

6.4 Sediment staining and the characterisation question

The photographic record includes areas of visibly distinctive sediment staining during the later operational and decommissioning chronology (Figures 8, 9 and 24). Colour alone cannot determine composition; red, brown, yellow and dark staining may arise from natural iron mobilisation, oxidation, disturbed soils, imported aggregate, standing water or operational materials, and this study does not assert contamination.

The significance of the staining is not chemical but procedural. It was a visible, distinctive material condition, present at known locations, at a known time, before restoration altered the surface. Where such material is present within a former hydrocarbon exploration site, the appropriate question is whether it was recognised, sampled, chemically characterised and formally classified before it was removed, covered, redistributed or incorporated into the restored soil profile. The decommissioning sequence sharpens this question: a section of perimeter ditch is shown opened, with the liner exposed and a tanker positioned beside the opened ditch with a hose extending into the excavation (Figure 19), and the same section is shown backfilled the following day (Figure 23). Between those two surveys, a visibly altered feature passed from accessible to buried. The records assembled for this study do not establish whether it was characterised in the interval.

This is the asymmetry of §6.1 made concrete. The original opportunity for contemporaneous characterisation was open and has since been substantially narrowed by backfilling and restoration. Whether anything was recorded while it remained open is a documentary question that should be answerable, or at least materially clarified, through operator, contractor, waste and regulatory records - not a matter of interpretation from imagery.

6.5 Restoration, verification and the meaning of baseline

Formal restoration establishes that specified works were completed and that the land was returned to an approved after-use. It does not, by itself, establish that earlier physical conditions were understood, that altered materials were classified, or that the restored land had returned to a defined environmental condition. Restoration and verification are separate processes acting on the same ground, and the distinction is not pedantic: visual reinstatement cannot answer questions concerning buried drainage, differential compaction, altered soil structure, redistributed sediment or persistent moisture pathways, and confirmation that a field has been reseeded does not establish that its behaviour matches undisturbed surrounding land.

Determining whether observed persistence represents normal recovery, expected construction legacy or an unresolved condition requires a defined expectation against which to compare – a post-restoration baseline or recovery trajectory specifying anticipated soil condition, drainage performance, vegetation recovery and surface elevation. The records available do not establish that such a trajectory was defined. In its absence, continuing differentiation can be dismissed as ordinary legacy without evidence, or over-interpreted as anomalous without evidence; neither is satisfactory, and the "compacted ground" explanation of §6.2 is an instance of the former.

A 2013 Environmental Impact Assessment scoping report proposed baseline characterisation covering groundwater quality and levels, ground-gas monitoring, groundwater–surface-water interactions and the predicted future environmental baseline. It also identified decommissioned-phase impacts and long-term borehole integrity following decommissioning as matters for assessment. The records presently assembled do not establish what elements of that proposed programme were subsequently completed, what data were obtained, or whether they were translated into a defined post-restoration recovery trajectory.

Proportionate verification would not presume continuing impact. It would establish whether the restored surface converges with surrounding land over time, retains expected construction-related differences, or develops patterns requiring further assessment – and it would do so against expectations defined in advance rather than reconstructed afterwards.

6.6 The test rather than the site

Grange Hill is useful not because the record establishes an exceptional outcome, but because it documents an ordinary regulatory endpoint - restoration and return to agricultural use - with an unusually extensive visual record. What is exceptional at Grange Hill is the record, not the process it documents; comparable endpoints elsewhere will more often lack any equivalent basis for assessment.

The transferable contribution is therefore the test rather than the site: a feature that recurs across season, across vegetation state and across independent methods of observation is a stronger candidate for investigation than one resting on any single observation, and this standard can be applied to restored industrial land generally. Where no systematic baseline, material record or post-restoration monitoring is retained, later differentiation becomes progressively harder to interpret, and the opportunity for a confident answer narrows. Where historical imagery, survey data, sampling records and restoration documentation are preserved, the behaviour of the restored landscape can be assessed rather than assumed.

Grange Hill therefore supports a modest but consequential proposition: restoration should be treated not as the end of an operational site but as the beginning of a distinct post-operational phase, in which material history, surface recovery and longer-term landscape behaviour remain capable of verification – provided the record required to verify them is secured before, not after, the ground that holds it is disturbed.

7. Further work

The observations in this study identify locations and questions suited to further investigation rather than resolving them. Several lines of work would materially clarify the conditions documented here.

Where the surface remains accessible, direct examination at the locations identified through cross-method recurrence – principally the field east of the former pad (Location C) and the former drainage alignment – would establish whether the persistent signatures correspond to differences in soil structure, compaction, moisture retention or buried material. Shallow soil profiling and sampling along and across the former drainage line, compared against undisturbed surrounding land, would test the ordinary "expected legacy" explanation directly rather than leaving it as an assumption. Repeat elevation survey would establish whether the differences seen in the 2018–2022 LiDAR comparison are stable, diminishing or developing, and would help separate genuine ground change from epoch-specific survey artefact.

Independent of any fieldwork, the documentary question raised in §6.4 and §6.5 remains open and answerable. A 2013 Environmental Impact Assessment scoping report proposed a programme of baseline characterisation and decommissioning-phase assessment, including consideration of monitoring requirements, future baseline conditions and long-term borehole integrity. Whether that programme was completed, and whether its outputs were used to define and verify a restoration trajectory, is a matter of record. The following documents would either resolve these questions or demonstrate their absence:

- the final Environmental Statement, if produced;
- the hydrogeological conceptual model;
- data from the four monitoring wells installed prior to scoping;
- groundwater-level and groundwater-quality time series;
- ground-gas monitoring results;
- the predicted future baseline;
- decommissioning-phase risk assessments;
- the site closure plan;
- restoration drainage and soil-reinstatement specifications;
- any assessment of long-term borehole integrity.

Whether the visibly altered material exposed during decommissioning was sampled, characterised and classified before it was covered or removed is a related question recorded – or not recorded – in operator, contractor, waste-handling and regulatory documentation. Establishing what contemporaneous characterisation exists would either resolve the question or demonstrate its absence.

Finally, the approach applied here – testing whether a feature recurs across season, vegetation state and independent method before treating it as a candidate for investigation – is transferable to other restored sites where comparable historical imagery and elevation data exist. Its value lies less in any single site than in providing a repeatable basis for assessing restored land where systematic baselines were not retained.

AI assistance disclosure

Generative AI-based language tools were used to assist with document structure, drafting refinement and consistency checking. They were not used to generate primary evidence or determine analytical findings. All observations, interpretations and conclusions were reviewed and remain the responsibility of the author.

Appendix A. Contemporaneous observations from the surrounding landscape

Taken together, these images show that visually distinctive water and vegetation conditions were present in the landscape surrounding the pad during the decommissioning chronology. Several features recur at identifiable locations or display coherent spatial geometry rather than appearing solely as isolated points. The available record is insufficient to determine whether these observations reflect ordinary agricultural and meteorological variation, pre-existing drainage and ground conditions, consequences of site construction or operation, or some combination of factors. Their inclusion therefore defines an open question rather than a conclusion.

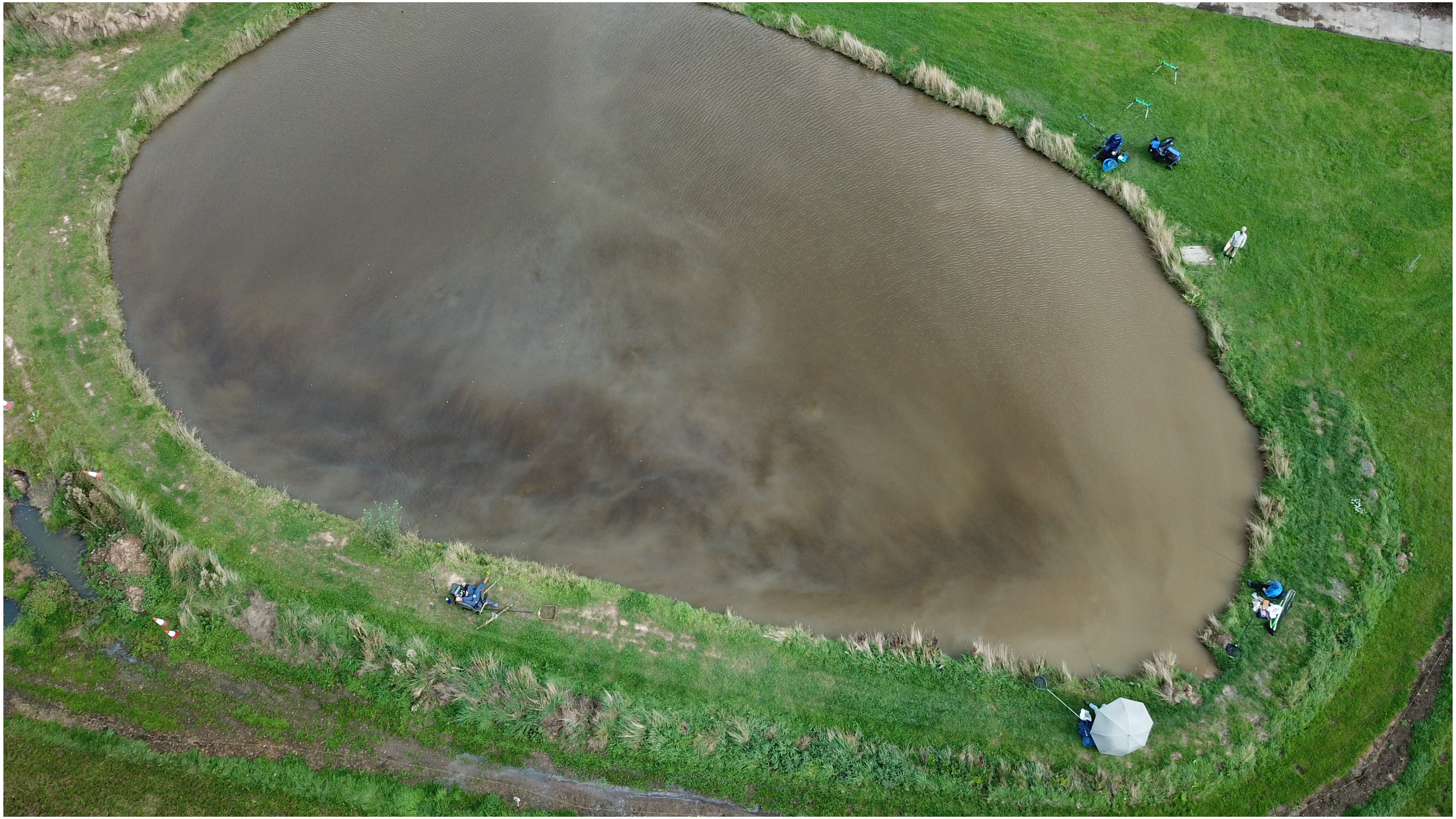

Figure 37: 13 September 2018. Dark internal tones are visible within a pond near the former wellsite.

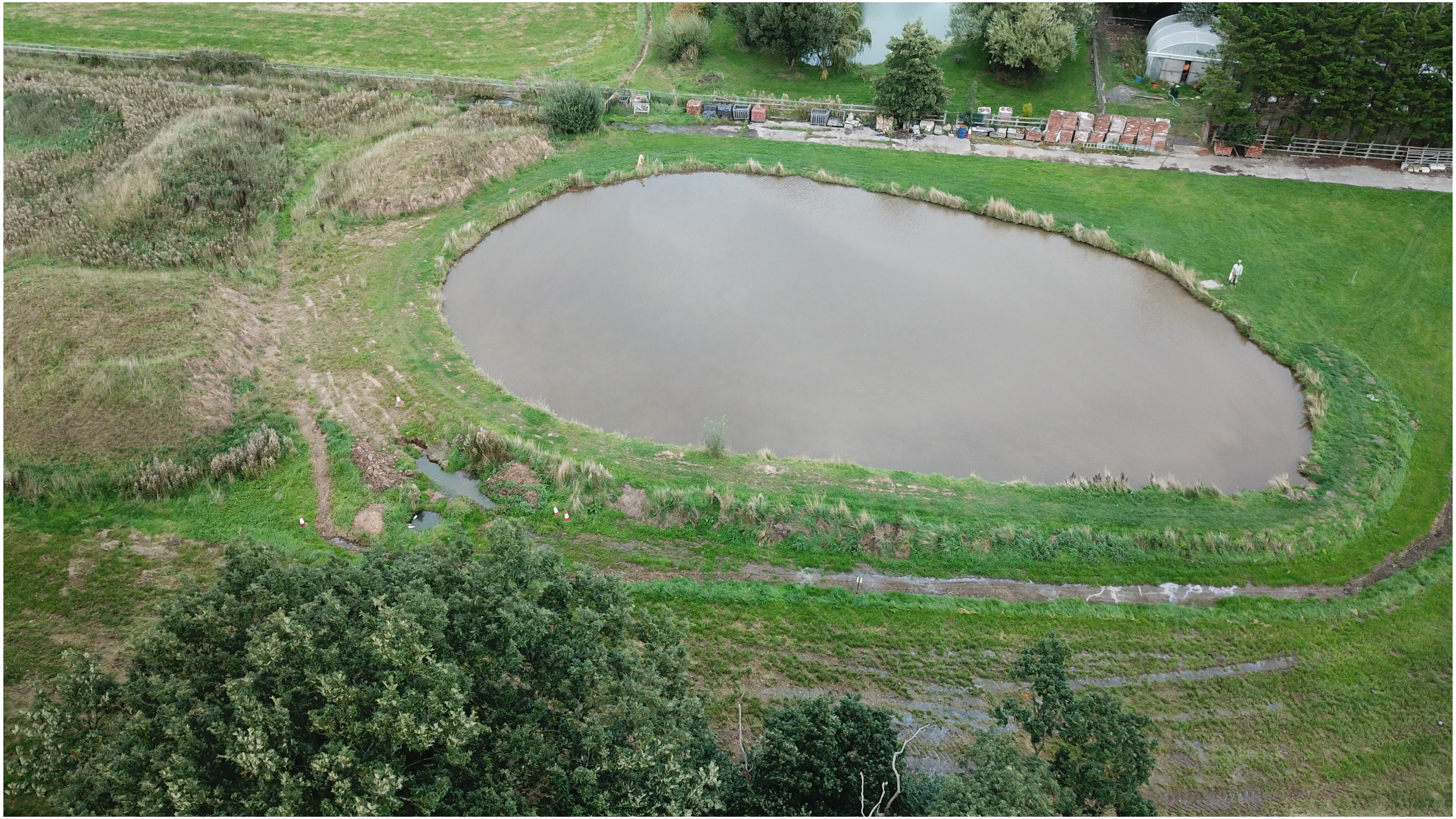

Figure 38: 14 September 2018. The same pond photographed the following day. A bright, silvery reflection is visible along the nearest pond margin and within adjacent saturated ground.

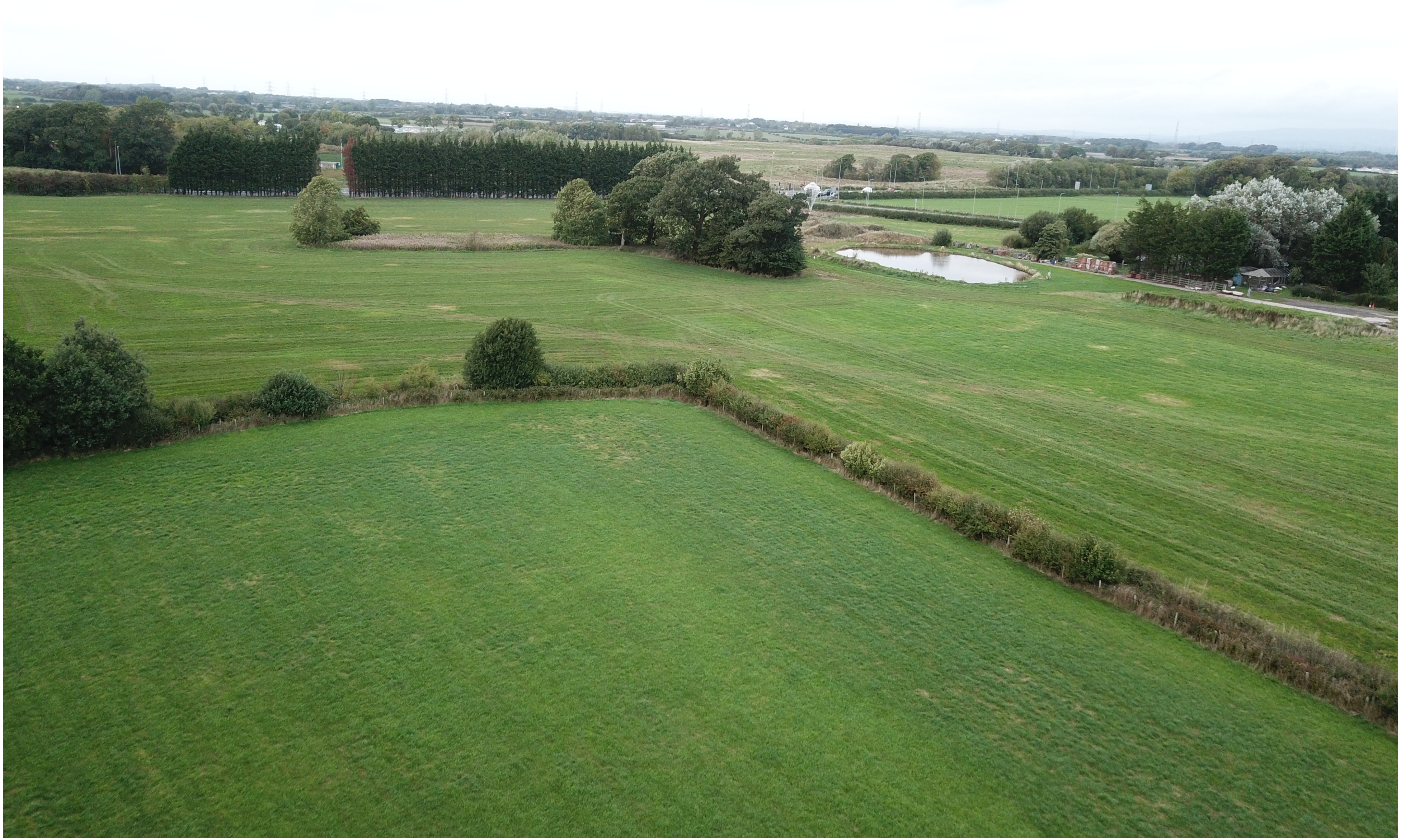

Figure 39: 14 September 2018. Oblique view of the pond facing north-east. Patchy crop growth is visible within the adjoining field.

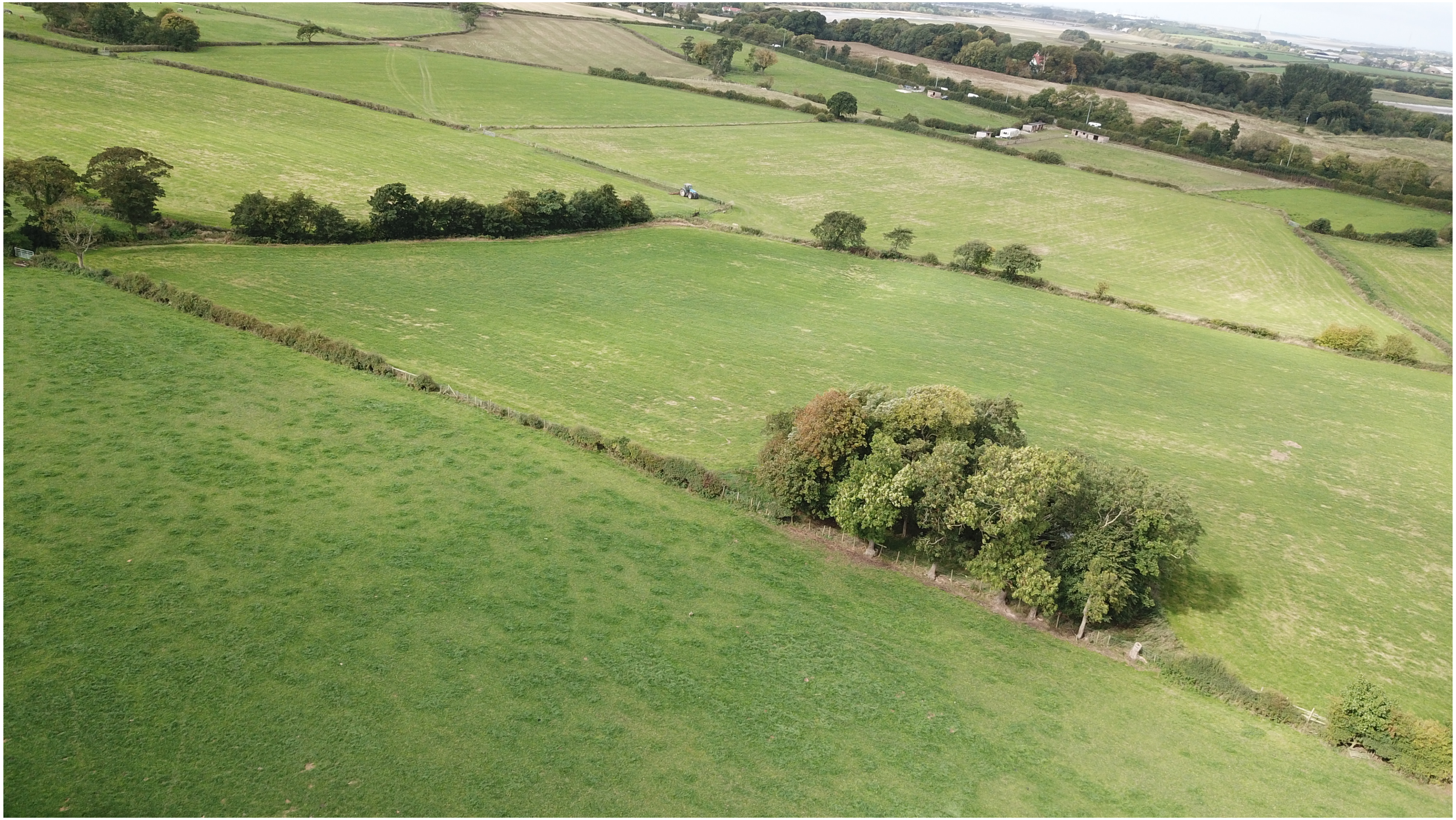

Figure 40: 14 September 2018. Wider view showing patchy and spatially variable vegetation across fields within the local drainage catchment.

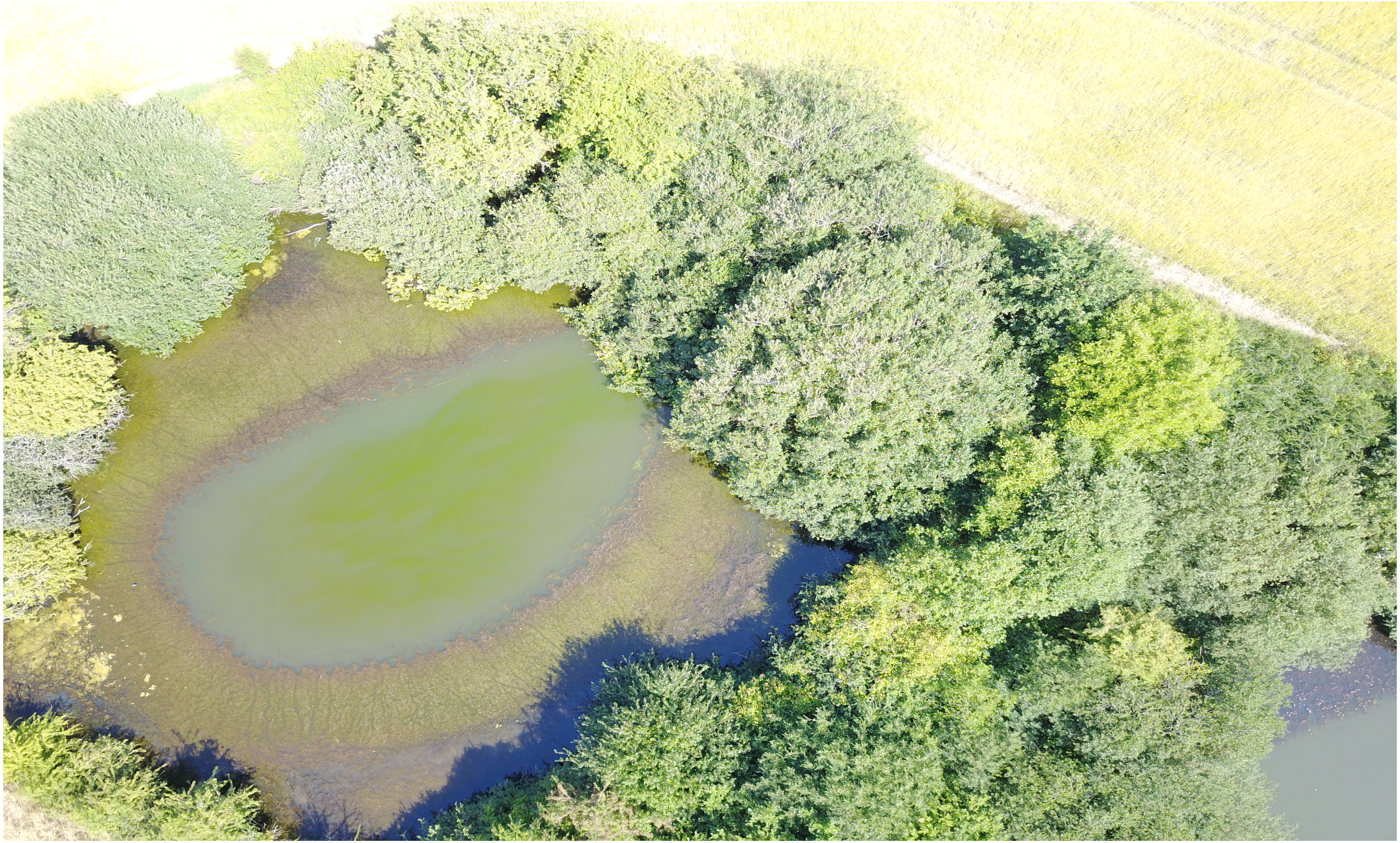

Figure 41: 19 July 2018. The pond displays a distinctly yellow-green water colour, most concentrated toward the centre and grading to a warmer brownish-olive at the shallower margins where submerged material is visible. A secondary water body at the lower margin shows a markedly different, darker tone.

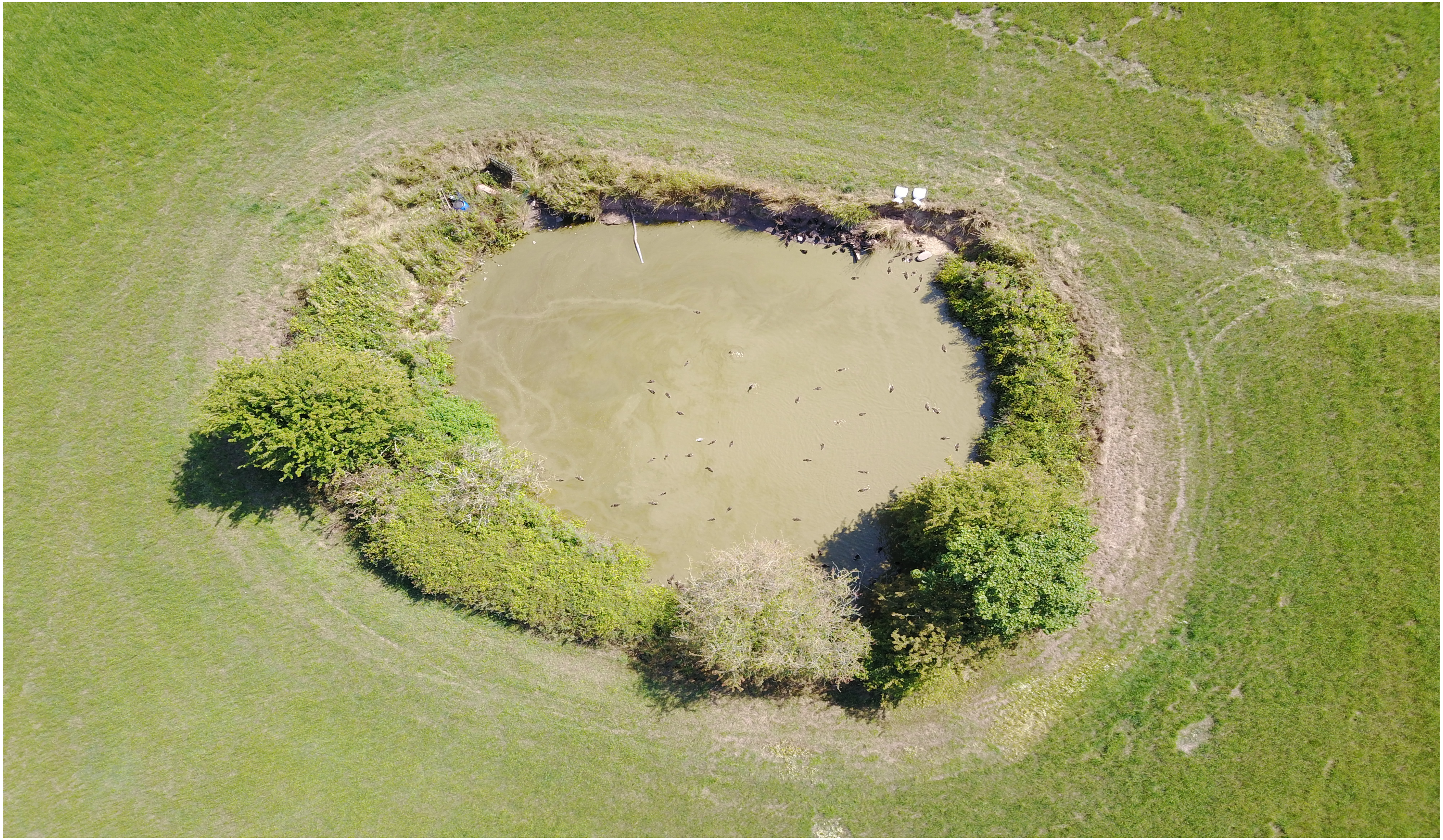

Figure 42: 19 July 2018. The open field pond, photographed the same day, displays uniformly turbid, grey-brown water. Concentric tonal banding is visible in the surrounding grass, with patterns of vegetation disturbance visible. Numerous waterfowl are present on the pond surface.